VOL III NO 4

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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"Non-Gran will run hotter without scoring than any other bronze we have ever used. In fact, in our experience with Non-Gran we have never had a scored bearing."

THE original letter from which this excerpt is taken bears the signature of a marine motor manufacturer whose opinion carries the weight of knowledge and experience.

HIGH SPEED
NON-GRAN
BEARING BRONZE

AMERICAN BRONZE CORPORATION
Berwyn Pennsylvania

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. III October, 1918 No. 4

The INSTITUTION OF AUTOMOBILE ENGINEERS WAR-TIME ACTIVITIES

THE work being done by the Institution of Automobile Engineers in England is in many ways closely parallel with that of the Society of Automotive Engineers. At the beginning of the war the members of both organizations showed the same enthusiastic desire to assist their Governments in every possible way. Both had the same difficulty in deciding whether their duty was to get into active service or to remain at home doing the equally important and essential work of the factories. The I. A. E. has done a great deal of good work in placing its members in various departments of the Government. Similar activities have been carried on for the S. A. E. through the Washington office. The I. A. E. has been successful in carrying on its regular professional meetings, and in having presented at them technical papers of the greatest value to its membership. In the same way the S. A. E. has given before its national and local (Section) meetings many papers along war automotive lines, and thus of timely assistance to the membership. The program of technical meetings must be carried on in both countries in order to assure the advance in design and construction essential in order to obtain the necessary automotive superiority over the enemy.

Effect of War on Activities

At the time the war broke out a number of members of the Institution had made a voyage to Belgium, where they visited the Minerva plant in Antwerp and many other famous factories in Belgium, concluding with a trip to the field of Waterloo. Only a few days after this visit terminated Belgium was plunged into the horrors of war. When the time came for taking up the active work of the Institution in the autumn of 1914, it was found that the president-elect, the president, the immediate past-president and a large number of other members were already engaged in the military services, so that there was much discussion as to whether the regular meetings of the Institution should be resumed. Even in those early days well over 15 per cent of the membership was in the service.

It was finally decided, however, having regard to the great value and wide use of automobile vehicles in the war, that the normal activities of the Institution should by all means be continued. The success of the meetings held since that time and the high standards maintained in the professional papers presented, despite the large number of members in the service who have been unable to take part in the work, have certainly justified the course adopted and are also an indication of what can be done in the United States by the members of this Society.

The Institution of Automobile Engineers is an outgrowth of the Cycle Engineers Institute, an organization located for a number of years in Birmingham, England. The Institution was formed late in the year 1906 and from the very first has been devoted to the promotion of the science and practice of engineering as applied to every kind of mechanical locomotion, on land, on or in water, or in air. But although it has retained the name automobile through all the years in which the word has come to have a definite significance as applying to a self-propelled road vehicle, the Institution has always been truly "automotive" in its purpose. This is shown by the many papers presented on the theory of flight, on internal combustion engine boats, on agricultural motors (called in this country farm tractors), steam-propelled road vehicles, and, as well, on all the different phases of automobile engineering.

The membership of the Institution is now well over 1000 and has increased steadily since the war. At the end of 1907 there were only 202 members. The Institution consists of honorary members, ordinary members, associate members, graduates and associates. There are only two honorary members, one of whom is Major Howard C. Marmon, who was president of the S. A. E. in 1913 at the time the I. A. E. members visited this country. The ordinary and associate members are required to have training as engineers and a certain experience in engineering as applied to mechanical locomotion. The graduates, who correspond to the Juniors of the S. A. E., are required to take an examination before admission, while Associates must have some interest in mechanical locomotion.

Graduate Section Work

The regular meetings of the Institution are held in London, but local Sections known as the Centers also hold meetings from time to time. There are now three of these, known as the Midland, North of England and Scottish Centers, with headquarters at Birmingham, Manchester and Glasgow respectively. A feature of the work of the Institution is the activities of the so-called Graduate Section, of which there are centers in London, Coventry and Birmingham. These hold technical meetings at which the papers are presented, usually by the graduates themselves. One of the prime objects of

the Institution is to assist in training the younger generation into whose hands the future development of the industry will come.

In the days before the war the Institution made a number of official visits to foreign countries, the last of these being the one to Belgium previously mentioned. In addition two visits have been made to France, and in the summer of 1913 a party of some 28 members of the Institution and friends participated in a trip to this country. Here they visited all the important manufacturing centers and attended the 1913 Semi-Annual Meeting of the Society, at which members of the Institution presented four of the papers. After the return of the party to England the Council of the Institution of Automobile Engineers presented to the S. A. E. a silver-mounted mahogany reading desk to show their appreciation of the welcome extended to them; this desk is now in the headquarters of the Society in New York. The visit of the members of the Institution to this country was in a sense a return to one made by members of the Society in 1911, when Past-President Howard E. Coffin read a paper before the Institution of Automobile Engineers and S. A. E. members inspected a number of plants in England and also attended the Olympia show in London. When the war broke out preliminary arrangements were being made for another visit of S. A. E. members to England and it is hoped that this interchange of international courtesy can be made at some later date.

British Standardization Work

The committee activities of the Institution have been various, important work having been done in preparing specifications for petrol (gasoline), determining data on flight, collecting information on aircraft design, investigating engine performance in order to fix a horsepower formula, and finally in cooperating with what is now the British Engineering Standards Association. This latter was formerly the Engineering Standards Committee, but the name has recently been changed in order to emphasize the international character of its work. The reports adopted by the Association will be printed in French, Spanish, Italian and Russian, as well as in English. These reports will then be sold at a uniform price of one shilling. The work of translating the reports is being supported by the British Government in order to assist the engineering industries of the United Kingdom in extending their foreign trade.

The Institution is now working with the British Engineering Standards Association in what is known as the Technical Committee of the Motor Industries. This is a joint committee on which are representatives of the Society of Motor Manufacturers and Traders and the Institution of Automobile Engineers. The Technical Committee does the work of the standardization, technical, and research committees of the S. M. M. T. and the steel and standardization committees of the I. A. E. It is associated with the British Engineering Standards Association and has done some valuable work in formulating specifications for automobile and aircraft steels. While the results of this activity have thus far been published only as an interim report (No. 75, B. E. S. A.), it is understood that an immense amount of research work has been done in order to prepare definite and accurate specifications and that these will probably be made public in full in the near future.

Noteworthy Technical Papers

Another work of the technical committee is in the investigation of fuel for automotive uses, this being carried on by a sub-committee which is cooperating with the government organization charged with the development of British natural resources. Rims for pneumatic and solid tires have also been standardized.

The Proceedings (Vol. XI) of the Institution of Automobile Engineers, recently received from England, includes a series of noteworthy technical papers given before the Institution during the session of 1916-17. The papers and addresses are a most significant indication of the way in which our English brothers are "carrying on" their engineering activities. They include the presidential address of Mr. L. A. Legros, which covers a wide range of subjects, such as a historical survey of the decrease in weight of many different types of internal-combustion engines, a discussion of the needs of scientific education, and a consideration of industrial conditions in England. Among the other papers are Mr. A. Ludlow Clayden's (M. S. A. E.) article on "The Electrical Equipment of a Car," applying especially to American starting and lighting systems; Mr. F. W. Lanchester's discussion of worm gears and worm-gear mounting; a contribution by Col. R. E. B. Crompton on the use of screw gages; Mr. F. Leigh Martineau (M. S. A. E.) has a paper on "Hydraulic Transmission," outlining the various types in commercial use, particularly as applied to automobiles.

The interest of the I. A. E. in aeronautic work is shown both in Mr. Legros' paper, in which he pays considerable attention to aeronautic engines, and in a paper describing some tests of model propellers by Mr. J. Lawrence Hodgson. A paper by Lieut.-Col. R. K. Bagnall-Wild and Lieut. E. W. Birch, entitled "The Use and Abuse of Steel," traces the development of the heat treatment of special alloy steels for aircraft construction. The last paper, by Messrs. A. W. Reeves and Cecil Kimber, on "Works Organization," appeared in the July, 1917, issue of THE JOURNAL.

The session of 1917-1918 has been equally productive of professional papers. The first meeting of the season last fall was devoted to the Presidential Address by Lieut. Col. R. K. Bagnall-Wild. This was followed at later meetings by papers on photo-elasticity by Prof. E. G. Coker, the design of a small farm tractor by A. E. L. Chorlton, an outline of a method of classifying data of the automobile industry by Ernest A. Savage, a paper on nomography in engine design by F. L. Martineau, one on some experiments on notched bars by Capt. H. P. Philpot, one on commercial steels and their heat treatments by J. B. Hoblyn, and two papers delivered at the last meeting of the year. One of these was read by the president of the Institution, Lieut. Col. R. K. Bagnall-Wild, on an examination into the causes of failure of lorry parts in war service, and the other was given by George W. Watson, member of the I. A. E. Council, on tank engines.

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Ignition Magneto Construction

By H. R. Van Deventer* (*Member of the Society*)

Mid-West Section Paper *Illustrated with* Charts and Photographs

MOST magneto troubles in the field are due to mechanical defects rather than to electrical faults or features of design. Magnetos of widely different types and constructions may prove equally effective so far as producing a spark is concerned, but on account of mechanical defects one type or make may give continued service for years while another will fail after a few weeks of service. The paper reviews briefly certain features of magneto construction and adjustment.

Magnetos may be roughly divided into two types, low-tension, as used on engines having make-and-break igniters, and high-tension or jump-spark types, as used on engines having spark-plugs. The low-tension types are seldom used on engines having more than one cylinder, while high-tension magnetos are used on engines having one or any number of cylinders, and with these cylinders arranged at various angles.

Low-Tension Magnetos

Low-tension magnetos are made in various sizes. Fig. 1 shows a type that was invented for rotary service and is adapted to from the smallest to the largest engines. The smallest machine weighs 4 lb., 11 oz., the largest 20 lb., 11 oz. The former is used on small engines and the latter on large engines and also extensively on the multi-cylinder marine engines of submarine chasers.

Low-tension magnetos are furnished for oscillating service (Figs. 2 and 3). The word "oscillator" has been widely and commonly applied to this type of magneto, these having been developed abroad where they are still extensively used, although they have become common in this country during the last few years.

While the oscillators shown in Figs. 2 and 3 are built with two springs, this type of magneto is often furnished with a single vertical spring, which practice, however, is becoming obsolete.

In recent years types of oscillating magnetos have been developed in which the magneto and make-and-break igniter are combined in a single unitary structure. One such arrangement, commonly known as the "plug-oscillator," is shown in Fig. 6. The magneto is of the low-tension wound-armature type, but the actuating mechanism is mounted entirely on the supporting bracket, thereby relieving the magneto of any strain. This actuating mechanism also operates the igniter. Fig. 4 shows the plug-oscillator mounted on an engine.

Devices of this type represent the highest development of make-and-break ignition equipment, the combination of magneto and igniter being very compact. There are few parts to wear, and the unit may be taken off the engine and operated by hand to ascertain if it is working properly. There is little chance for the igniter and magneto to become unsynchronized, and the engine and the device can be removed and replaced as a unit without adjustment or resetting of the timing.

Figs. 5 and 6 show front and side view of a complete plug-oscillator equipment. The left-hand figure shows the magneto removed. The large nut at the top clamps the plug-oscillator on the engine. The nut at the extreme left is part of the binding post to which the wire from the magneto connects. The magneto as a unit is removed from the bracket by taking out the bottom bolts. When so removed it is impossible to replace it incorrectly timed as the bifurcated member on the magneto shaft merely slips off of the spring pins and there are no adjustments of any kind to make.

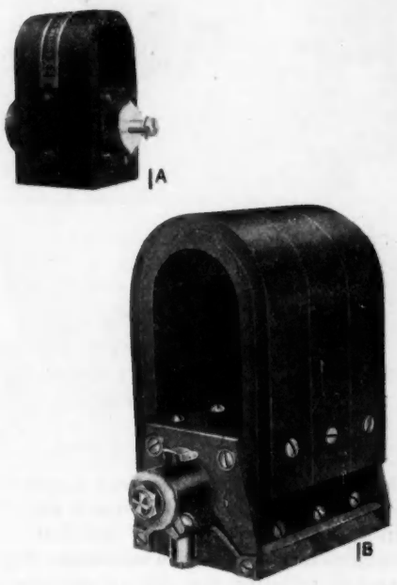


Fig. 1—Typical Small (Left-hand) and Large (Right-hand) Low-Tension Magnetos

Fig. 9 shows how the plug-oscillator is timed with the engine. The "early" and "late" eccentric *A* is turned so that the letter *E* is up, indicating the early spark position, then the flywheels are rotated in the direction in which they run while the inlet valve is held open with the finger until the plug-oscillator snaps. The spark mark on the flywheel should then be opposite the exhaust rod. If not, the clamp nut *R* should be loosened and the trip finger mechanism adjusted forward or backward on the exhaust rod as may be necessary.

High-Tension Magnetos

Turning now to the high-tension magneto we find a much larger number of types and sizes, owing to the requirements of the engines on which such magnetos are used. Fig. 7 shows a small high-tension magneto for single-cylinder engines. This same machine equipped with an end plate for the springs becomes a small oscillator, as shown in Fig. 8. A magneto for two cylinders is practically the same in appearance as the one-cylinder machine. Fig. 10 shows a magneto for a six-cylinder en-

*Splitdorf Electric Company, Newark, N. J.

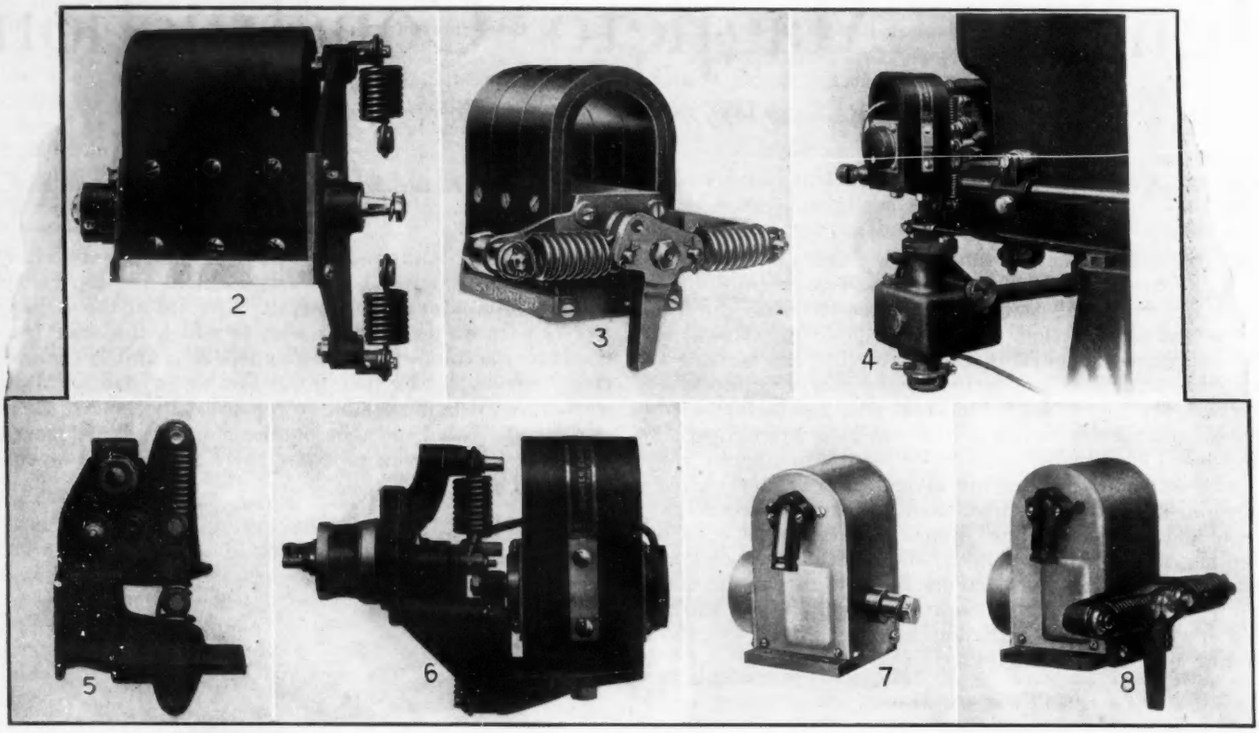


FIG. 2—LOW-TENSION OSCILLATING MAGNETO WITH VERTICAL SPRINGS. FIG. 3—LOW-TENSION OSCILLATING MAGNETO WITH HORIZONTAL SPRINGS. FIG. 4—PLUG-OSCILLATOR MOUNTED ON AN ENGINE. FIG. 5—END VIEW OF FIG. 6 FROM MAGNETO SIDE (MAGNETO REMOVED). FIG. 6—SIDE VIEW OF PLUG-OSCILLATOR EQUIPMENT. FIG. 7—HIGH-TENSION MAGNETO FOR SINGLE-CYLINDER ENGINE. FIG. 8—HIGH-TENSION OSCILLATING MAGNETO

gine. The four-cylinder type is practically the same in outward appearance. The four and six-cylinder types are extensively used on trucks and tractors.

AIRPLANE MAGNETO TYPES

Fig. 11 shows an eight-cylinder type airplane magneto. Fig. 12 shows this magneto with covers and distributor removed. In addition to furnishing ignition current, this magneto furnishes current for the wireless. Fig. 13 shows a magneto and distributor for use on engines of the Le-Rhone and Gnome type. This magneto produces two sparks per revolution, and is driven 2¼ times engine speed on a four-stroke cycle, nine-cylinder engine. Fig. 14 shows a magneto used with separately driven distributor and employing a small high-tension magneto for starting. This outfit is used on twelve-cylinder engines having a 45-deg. angle between the two rows of cylinders. The magneto operates 1½ times engine speed, producing sparks at 62½ deg. and 112½ deg. This same magneto is made to operate at engine speed, producing six sparks per revolution at equal angles of 60 deg. and when used on twelve-cylinder engines of conventional design the distributor may be mounted on the camshaft, thereby eliminating the distributor gear commonly incorporated in the magneto. The plan of ignition often adopted for airplanes contemplates the use of two magnetos for each engine, each magneto producing a spark in each cylinder at the same time. The magnetos are commonly set on the engine so that the spark occurs from 23 to 28 deg. ahead of the dead center position. Some idea of the general arrangement of the magnetos on a modern airplane engine will be gathered from Fig. 15. Fig. 16 shows a complete wiring diagram for an airplane engine, including radio connections.

Magneto Construction

From the foregoing hasty review it will be noted that to meet the requirements of internal combustion engines magnetos must be of many sizes and types. This should be kept in mind when considering the following data which are of necessity general in character. There are certain points necessary from a mechanical point of view that must be given careful consideration in any magneto, whether it is intended for use on a stationary farm engine infrequently run and making a few hundred revolutions per minute, or in battle airplanes running for hours at high speed. In addition to these general requirements each size and type of magneto has certain mechanical details worthy of careful study. These details, however, it is impossible to cover in a paper of this character.

All magnetos have magnets. Prior to the war, steel

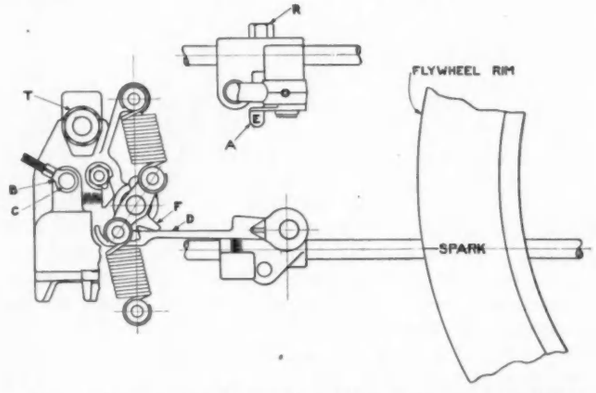


FIG. 9—METHOD OF TIMING PLUG-OSCILLATOR WITH ENGINE

containing 5 per cent tungsten was used, but during the past two years chromium steel has been used with entirely satisfactory results as far as the life and efficiency of the magnets are concerned. The chromium steel is somewhat harder to work than tungsten steel.

The purchaser must take the magneto manufacturer's statements as to the tempering and magnetizing, and can do little more than inspect the magnets for workmanship, see that they are properly formed and ground to fit the pole pieces of the magneto, and that the grinding has not drawn the temper.

In the majority of low-tension magnetos the magnets are attached to the pole pieces by screws, and it is preferable that some means be employed to seal at least one of these screws so that the magnet cannot be removed from the magneto without breaking the seal, thereby showing when the magneto has been tampered with.

Magneto manufacturers know that in the majority of cases where magnets are reported dead, 99 per cent of the trouble is due to the battery having been connected to the magneto, thereby demagnetizing the magnets. Other troubles are caused by taking the magnets off the magneto without applying a keeper, or by replacing them wrongly.

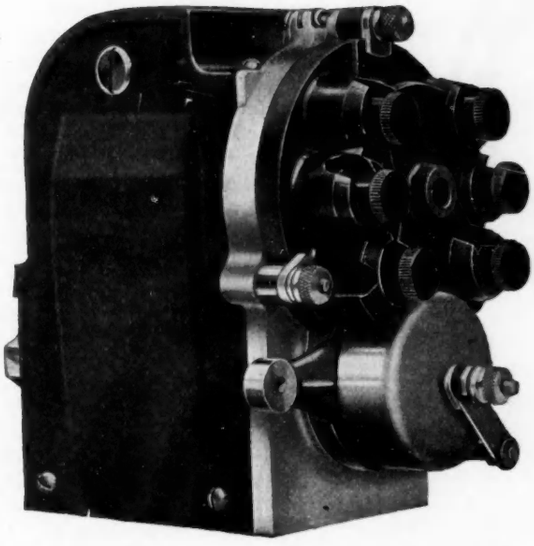
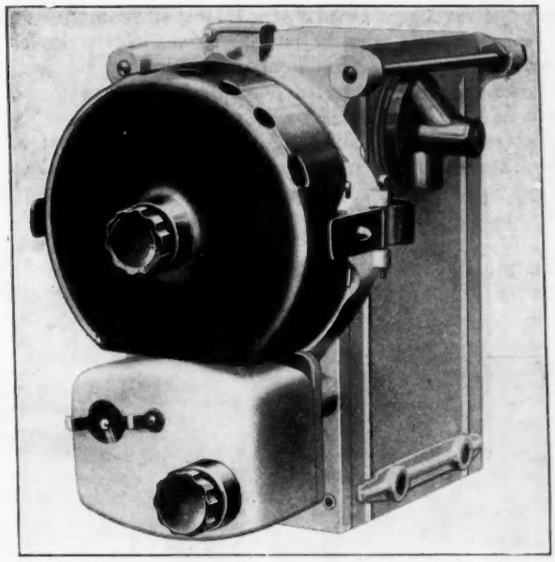


FIG. 10—HIGH-TENSION MAGNETO FOR SIX-CYLINDER ENGINE

Method of Magnetizing

While methods of magnetizing do not come within the scope of this paper, it is thought that the latest practice in this connection will be of interest. Fig. 17 shows a magnetizing coil with the master magnet in place. These coils are supplied by the magneto manufacturer and are designed for various voltages, usually 110 volts, direct current being used in all cases.

The coils are connected up and so marked that the N and S poles are known, and all magnets of a certain make of magneto should be magnetized in the same direction. The magnet to be magnetized should be connected to the one in the coil and pushed forward so that it is covered by the coils, as shown in Fig. 18. The switch connecting the coils to the source of current should then be thrown in one second and opened while the magnet being magnetized is in the coils, as shown. After the switch is opened the magnet being magnetized should be



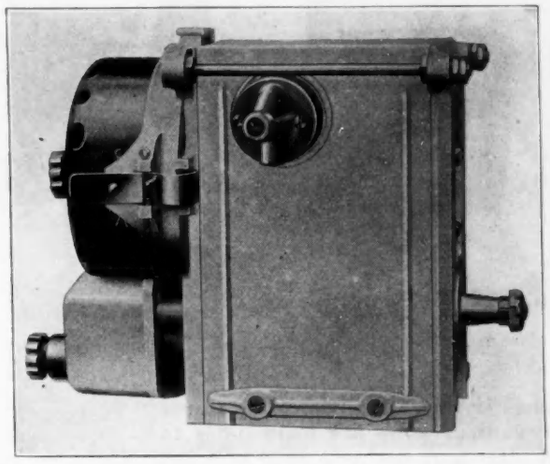


FIG. 11—TWO VIEWS OF MAGNETO FOR AIRPLANE SERVICE

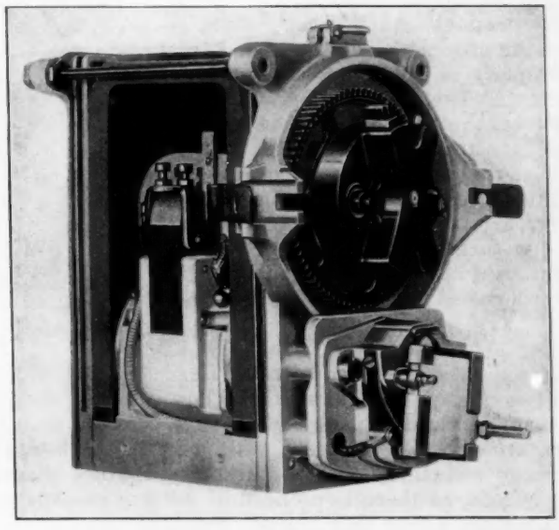


FIG. 12—SAME MAGNETO AS FIG. 11, SHOWING INTERIOR CONSTRUCTION

pulled forward and before separating it from the one in the coil a keeper should be placed across its poles, as shown in Fig. 19. This keeper should not be removed until the magnet is in its position on the magneto, as shown in Fig. 20. It will be found that magnets properly magnetized and not subjected to any mechanical abuse will retain their strength indefinitely unless the battery current is passed through the windings of the magneto.

Magneto Design

The question of design of the magnet proper is of considerable importance to the purchaser. As a general rule magnets having a considerable distance between their poles are more liable to short life than magnets in which the poles are closer together. Practically all modern makes of magnetos of the rotary high and low-tension types have well-proportioned magnets.

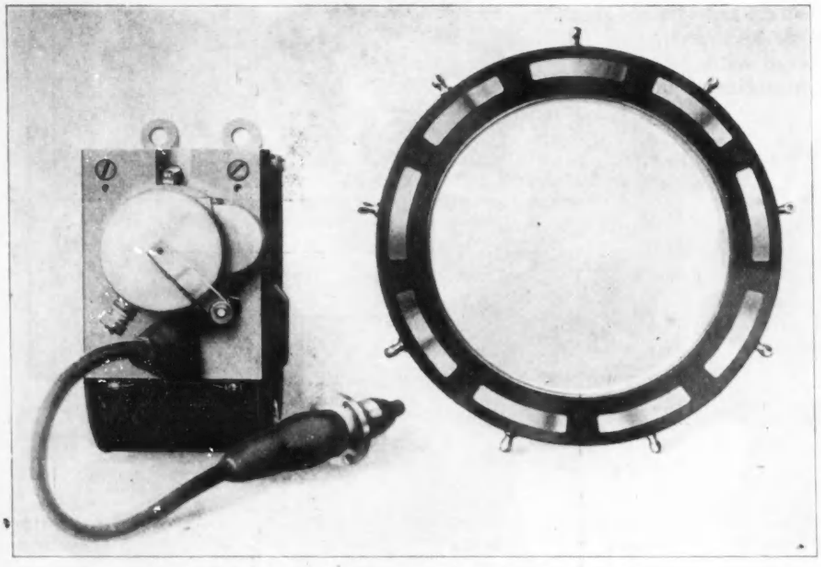


Fig. 13—Magneto Used with Le Rhone and Gnome Engines

The magneto manufacturer must secure the proper grade of iron and treat it properly or it will not be electrically efficient. The purchaser should note, however, that the air gap between the armature and rotor or pole pieces, is as close as is consistent with good mechanical practice, and that the construction of the armature or rotor and its bearings is such that this air gap will be maintained at all speeds and during the life of the magneto.

Types of Bearings

The magneto bearings are divided into two classes, plain and ball. Plain bearing magnetos are usually those of the low-tension variety, although there are several models of plain bearing high-tension machines recommended for stationary engines of ordinary speeds, as there is no need of putting in expensive ball bearings where they are not required.

The life of the plain bearing machine seems to be entirely dependent on the treatment the magneto receives; the purchaser should see that the oil holes are provided with suitable covers; and the best low-tension models are equipped with oil pots adapted to hold non-fluid oil, so that when once filled the magneto will run several months without attention. Wick oilers are used on the larger models and afford efficient and reliable means of lubrication. Lack of oil will cause the magneto shaft to stick and break.

Practically all magnetos for high-speed engines such as aeronautic and automobile are equipped with ball bearings. In some cases ball-bearing distributors are used. The usual methods of oiling are employed on most models. In some magnetos for relatively slow-speed work the bearings are packed with grease and put into the magneto and no provision is made for ever oiling them again. It is found that such bearings will give good service when properly protected from dirt.

Shuttle-type armatures have a clearance of about 0.005 in. The annular bearings are subject to wear from the following causes:

A broken ball will cut the ball races and in turn cause the armature to rub against the pole pieces. Lack of lubrication in either of the bearings will cause them to become cut and roughened, a new bearing being the only remedy. The grounded brush may be missing or dirty, causing the ball bearings to become pitted and rough. The back plate screws may become loose from excessive vibration, causing the armature to stick, with a resultant breaking of the drive shaft.

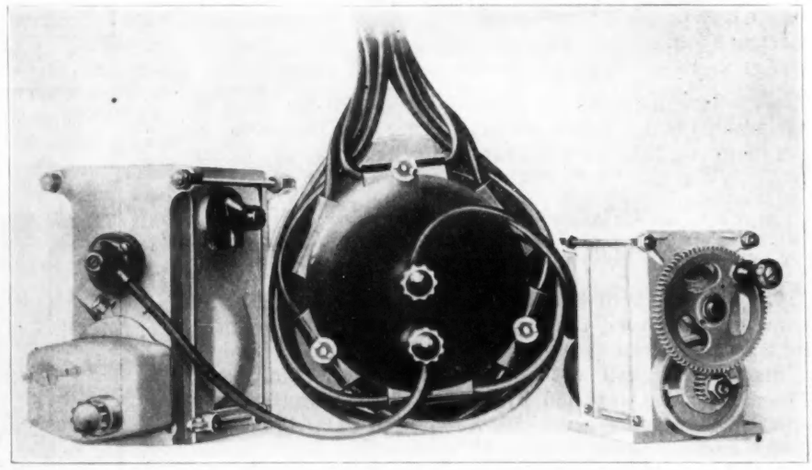


Fig. 14—Airplane Magneto with Separate Distributor and Starting Magneto

The coupling may not be flexible and will cause the bearings to wear sideways; the armature will rub on one end. This may also occur if the magneto is too much out of line. The bottom bolts may be drawn up too tight, causing the case plate to spring, with the result that the bearings are run tight and thus ruined. The twisting of the armature out of line may cause

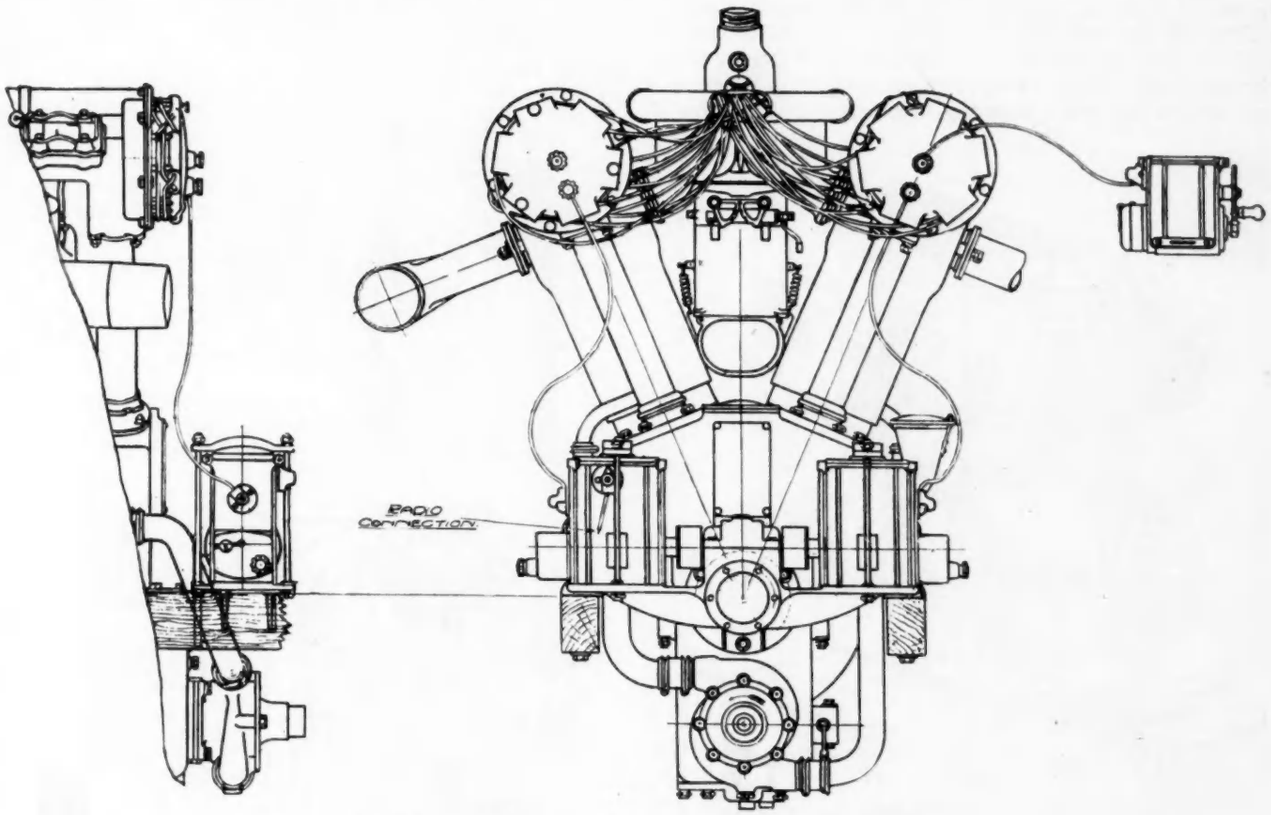


FIG. 15—ARRANGEMENT OF MAGNETOS ON AN AIRPLANE ENGINE

the winding to rub and chafe, grounding the winding. The four screws holding the armature heads may become loose or shear from the twisting strain and wreck the armature. The drive shaft may become loose, due to tight bearings or too great magnetic pull, or to faulty construction, especially if the drive end is made from other material than manganese bronze.

In the case of high-tension machines of the armature type the customer can do little more than inspect the armature for general workmanlike appearance. In magnetos of the stationary coil type, the coil can be inspected.

The windings on modern magnetos give little trouble if properly manufactured. The purchaser of low-tension models should take several of the samples submitted and have the armatures unwound to see that the winding is laid on in smooth layers and properly insulated from the armature core. When armatures are loosely wound the wire may slip, thereby causing short-circuits or binding of the armature.

TESTING MAGNETOS

In inspecting the windings and small insulating parts of magnetos through which high-tension current is conducted, a testing outfit, shown in Fig. 21, is of considerable value. A twelve-volt battery is used. Operating switch *A*, when closed, completes the battery circuit through the vibrator. The safety gap is set at 7/16 in. In testing out a part which carries high-tension current, for instance a spark-plug cable, connect the wire *M* to the wire of the cable and pass the wire *L* along the outside over the exterior surface of the rubber. Any rupture is very easily found in this way. The same rule also applies

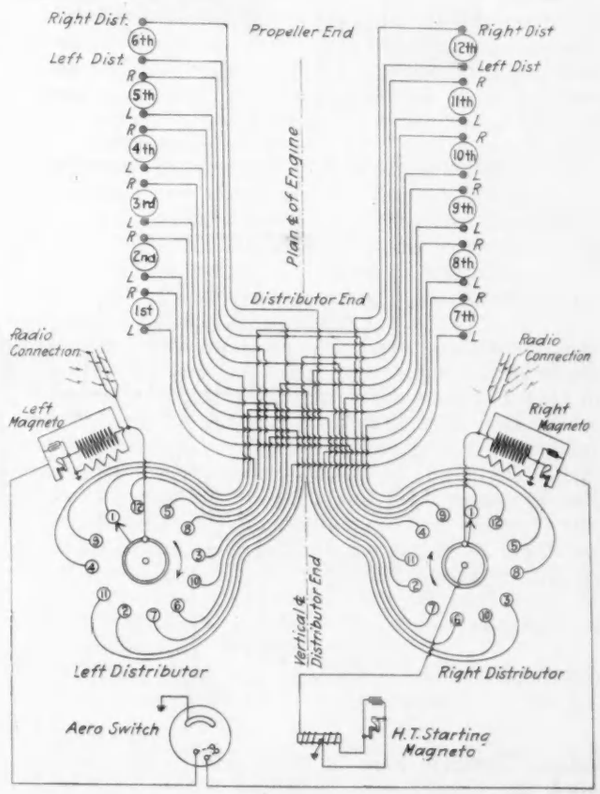


FIG. 16—WIRING DIAGRAM FOR AIRPLANE AND WIRELESS CONNECTIONS

to testing leaks in distributor spools, such as that shown in Fig. 22, one wire being connected to the brass segment and the other passed all about the insulation surrounding the segment. This is really nothing more than a mechanical test, as any crack in one of these spools will render it useless. Trouble here is often due to the surface on which the brush bears becoming rough. It should be smooth.

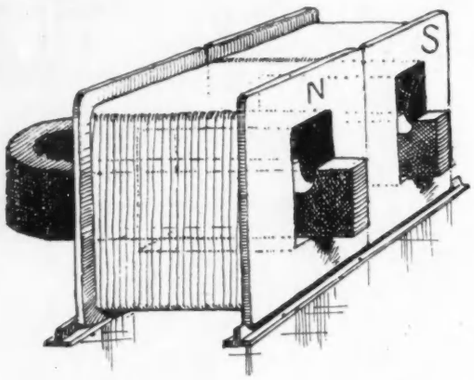


FIG. 17—MAGNETIZING COIL AND MASTER MAGNET

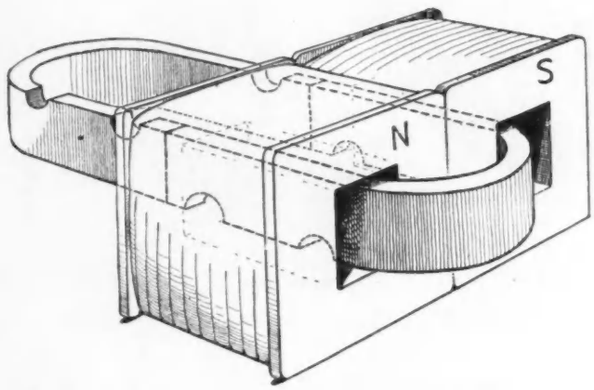


FIG. 18—METHOD OF INSERTING MAGNET IN MAGNETIZING COIL

Breaker Design

The interrupter mechanism, or as it is commonly called, the breaker, is usually mounted about the end of the magneto shaft and consists of a movable contact member adapted to open and close the primary circuit of the magneto. This interruption may take place once per revolution, or a number of times per revolution, depending upon the number of cylinders the magneto is designed for and the shape of the cam. It is very essential that the points separate when the rotor or armature is in a certain position in relation to the pole pieces. This

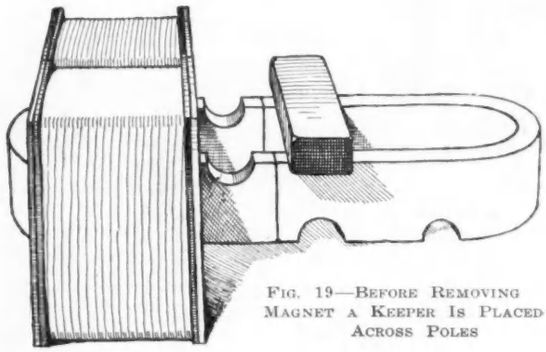


FIG. 19—BEFORE REMOVING MAGNET A KEEPER IS PLACED ACROSS POLES

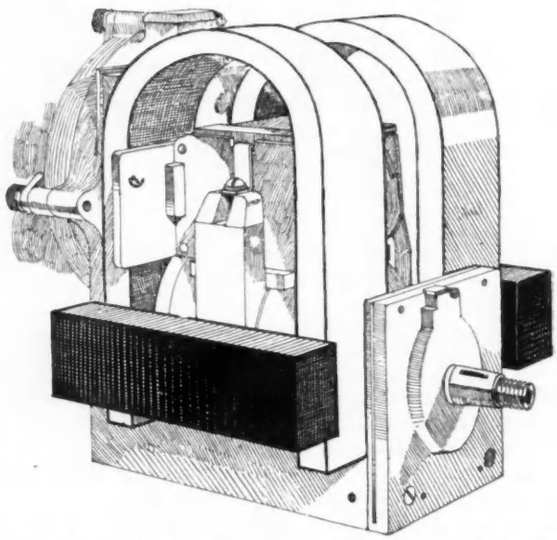


FIG. 20—ATTACHING MAGNETIZED MAGNETS TO MAGNETO BODY

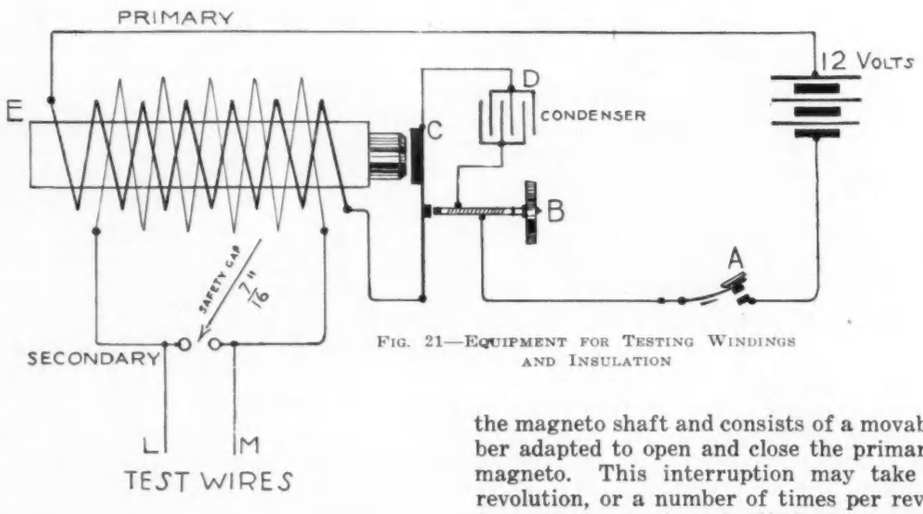


FIG. 21—EQUIPMENT FOR TESTING WINDINGS AND INSULATION

will be clear from a reference to Fig. 23 in which the gap between the edge of the rotor and the pole *H* is shown.

It is difficult to judge just when the contact points in a breaker open, as a movement of even as little as 0.01 in. which the eye cannot see, breaks the circuit; it is well to use a test buzzer, shown in Fig. 24. The magneto shaft is rotated as indicated by the arrow on the oil cap, which shows the running direction of the magneto. While the contact points are closed the buzzer circuit is closed, and the buzzer will operate until the contact points open. Just at that instant, when the buzzer ceases to operate, stop turning the magneto shaft and use a thickness gage, as shown, to measure the gap *X*. There is no adjustment more essential than this one if the most effective per-

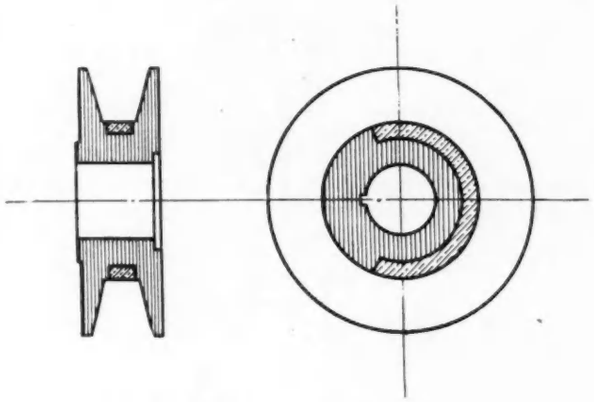


FIG. 22—MAGNETO DISTRIBUTOR SPOOL

formance of the magneto is to be secured, and it is obvious that only through correct mechanical work can this accurate adjustment be obtained.

Fig. 25 shows another important part, the breaker arm or lever, common to all magnetos. It is seldom that the platinum points will be found defective. Sparking at the points is usually due to oil, misadjustment or a defec-

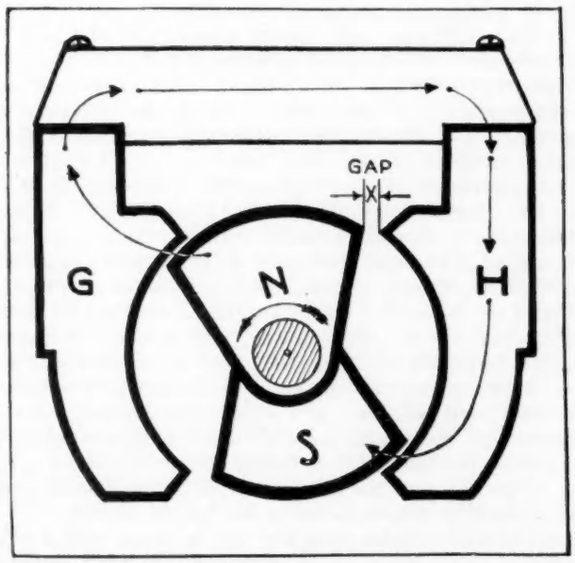


FIG. 23—SHOWING GAP BETWEEN EDGE OF ROTOR AND POLE PIECE

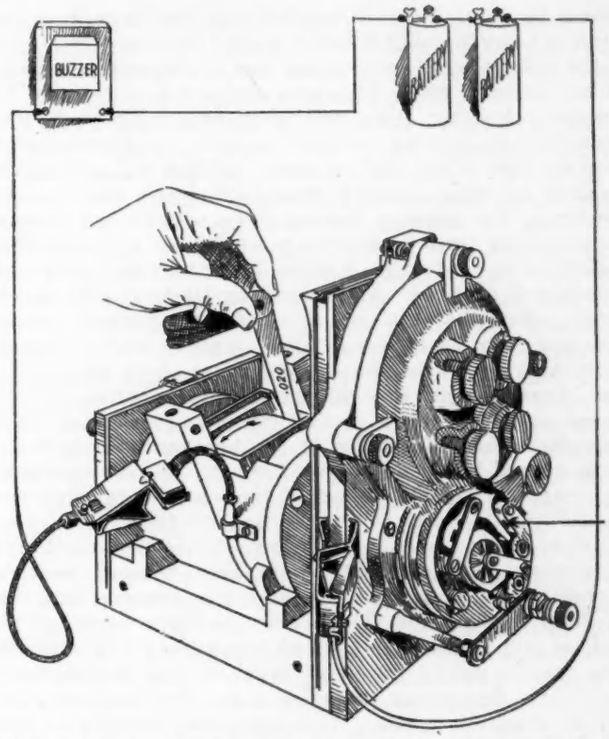


FIG. 24—BUZZER EMPLOYED FOR SETTING BREAKER CONTACT POINTS

tive condenser. The main thing is to see that the points are clean and not loose.

The fiber bumper may become loose in the breaker arm, and purchasers should examine this part very carefully to ascertain how the bumper is secured in place and if it can be removed in case of wear. New bumpers should always be filed to fit the cam. That edge which the cam first comes in contact with should be filed until the contact points separate, when the gap between the rotor and pole pieces is in accordance with the limits given by the manufacturer. The breaker construction must be such that the breaker bar cannot become tight on its stud and thereby stick in the open position. Sometimes this occurs because of insufficient lubrication. Some magnetos have the breaker bar mounted on a hollow pin, which communicates with an oil hole in the edge of the breaker box, through which oil may be applied.

Breaker boxes on most magnetos are movable for advancing and retarding the spark, and on machines where the breaker box *only* is moved, attention should be paid to the way the box is secured, so that it will move easily without binding and at the same time not wobble about the cam. In the stationary-coil type the breaker box is secured to and moves with the field structure and therefore sticking is impossible. This feature also makes it possible to secure the same degree of spark intensity with the magneto, either full advance or full retard, as the relation of the gap *X*, Fig. 23, to the time of opening of the points is always the same regardless of the advance or retard position.

The troubles arising from mechanical defects in circuit breakers are numerous and may be caused by the following:

Insufficient lubrication of the breaker lever, causing it to stick and corrode. A loose breaker-bar bearing stud, due to faulty riveting. Breaker bar bearing stud too small in diameter, causing undue wear in the breaker

lever bearing. Breaker bearing stud too large in diameter, causing breaker lever to stick. Breaker-bar bearing stud or breaker lever wearing, due to electrolysis. Undue fiber bumper wear, the cams being too abrupt or too rough. Breaker lever too heavy or out of proportion, causing the bearing to wear rapidly. A breaker lever spring that is too stiff, causing the bearing and contact points to wear. Rapid fiber cam wear, due to dust entering the breaker housing. In a revolving breaker the breaker lever bearings are sometimes made of fiber, which will cause the breaker lever to stick under atmospheric changes. The insulating bushings of the contact screw bracket on a revolving breaker become cracked from heat, causing these parts to loosen. Breakers that revolve left-hand and have a right-hand screw or threaded bolt to hold them in place often become loose and are broken, or fall off and become lost. The greatest wear is usually in the breaker housing bearing, caused by road dust working in; the advance lever rod may be too stiff or out of line; a loose housing will cause the contacts to break out of time. The fiber bumper may become loose from shrinkage or faulty fastening. The contact points may become loose in breaker bars, or the breaker bars may become bent, due to light construction. The breaker bar may become crystalized and break. The ground connection of the breaker bar may be poor. Revolving breakers may become loose and turn, destroying the relation of the circuit breaker to the magnetic break. A breaker base fastening screw may be too long, puncturing the condenser or breaking the screw off.

Breaker fastening screws that are too large in the thread cut like a tap and fill up the inner end of the breaker sleeve with brass chips, short-circuiting it. Revolving breakers not running true will cause incorrect breaking of the contacts and wear the cams.

Mica Condensers

The purchaser can do little toward satisfying himself as to the quality of mica condensers. This is a matter which concerns the manufacturer. Fig. 26, however, shows how the condensers can be tested electrically.

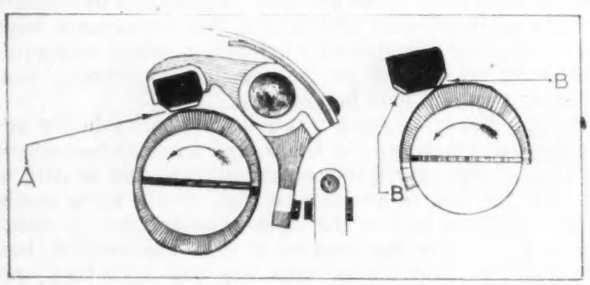


Fig. 25—Breaker Arm or Lever

There should be no electric current through the condenser when the switch is closed and therefore the lamp should not light. If the lamp does light the condenser is defective. Condenser trouble is rare in modern magnetos, and manifests itself in flashing at the points and failure of the spark.

Distributor Design

The distributor whereby the spark produced by the magneto is led to the several cylinders should receive careful attention, for here mechanical defects are often found. In the first place the material in a distributor should be of high insulating quality, should be impervious to moisture, readily cleaned and not affected by heat. It should also be mechanically strong to withstand the abuse to which it is often subjected.

No attempt will be made here to discuss the relative merits of distributors having a single traveling brush as compared with those in which there is one brush for each cylinder and a single traveling contact; nor will the gap type of distributor in which a rotating finger passes near a terminal for each cylinder, a gap intervening, be discussed, as such arrangements merely side-

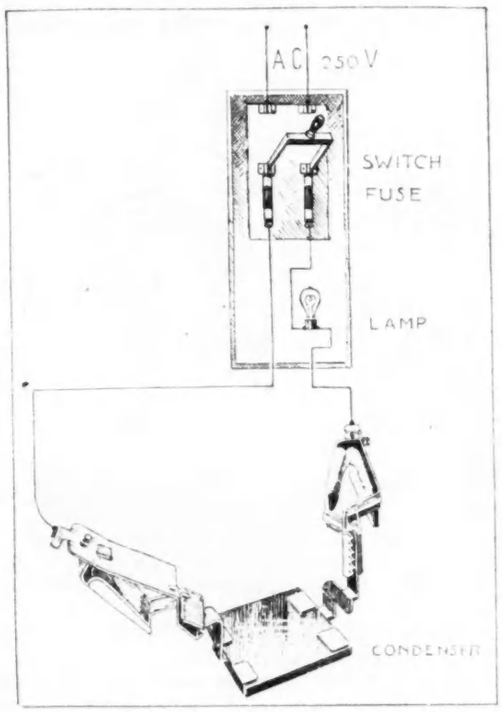


Fig. 26—Equipment for Testing Condensers

step the distributor problem. An actual contact is necessary, and while gap distributors eliminate brush trouble, they introduce other much greater evils.

The various parts of the distributor should be inspected by the customer to determine whether or not they are properly proportioned. For instance, the length of the contact segment in the distributor disk is a matter of vital importance, and some manufacturers in their endeavor to offer a distributor having a very limited amount of travel, or to squeeze a twelve-cylinder distributor into very small limits, have shortened up the contact segments. Why this should not be done, will be evident by referring to Fig. 27, which also shows the results of a wrong setting or meshing of a distributor gear on the rotor shaft. The left-hand figure and also the middle view show what happens when the gear is improperly meshed, while the view at the right shows the proper setting. Suppose the manufacturer has used a short segment. The retard position of the contact distributor is shown at *A* (Fig. 28) and the advance position at *B*. Suppose the segment to be only half the length shown in the figure. It will be seen that the brush would run off the segment when advanced, which actually occurs in some magnetos.

Distributor bearings of the ball-bearing type usually become defective from improper adjustment and the shock of the armature flux reversal. Wear on bronze distributor bearings is usually caused by poor lubrication and the accumulation of dust from carbon brushes, also by clogging of the oil duct leading to the distributor bearing and the dirt in the oil cup, which finds its way into the bearing when the magneto is oiled. Insulated distributor parts out of balance may cause the bearing to wear oval. Too much tension on the thrust button spring causes excessive end-thrust on the bearing, resulting in heating and sticking. Bearings of a graphite material or oilless bearings have been tried with poor results, owing to the softness of the bearing material; they are also very noisy. Adjustable distributor bearing plates may become loose, causing bearing wear from too much back-lash or too tight meshing of the gears.

FIG. 27—CORRECT LENGTH OF CONTACT SEGMENT OF DISTRIBUTOR DISK (RIGHT-HAND DIAGRAM). OTHER DIAGRAMS ARE INCORRECT

FIG. 28—"RETARD" POSITION OF CONTACT DISTRIBUTOR AT *A* AND "ADVANCE" POSITION AT *B*

Distributor shafts that are hollow and carry fiber or hard-rubber secondary connections may have these parts out of line or sprung, causing wear in the bearing. An unusual amount of wear may result from the rough surface of an unfinished distributor shaft when plain bronze bearings are used. Plain bearings composed of other metal than bearing bronze wear rapidly and become noisy and chatter.

TESTS FOR MECHANICAL DEFECTS

Mechanical defects are usually found on inspection by a competent person. In low-tension models they consist for the most part of broken and bent shafts, cracked magnets and stripped threads in the bolt holes of the case. In addition to these, high-tension machines show cracked or loose distributors, breakers loose or out of adjustment, distributor fingers or brushes missing or broken.

No test will equal that of actual service. The manufacturer, however, uses certain mechanical tests; for low-tension magnetos, these usually consist of short-circuiting the magneto and running it for several hours at a speed of 400 to 500 r.p.m. This initial short-circuit will decrease the magnetic flux of the machine as far as it will ever be, and any tight bearings or other mechanical defects usually develop during the run. The magneto is then taken off and tested electrically, and is finally connected up to a make-and-break igniter and the spark observed visually.

The testing of a high-tension magneto is somewhat more difficult. One four-cylinder machine is first oiled and the distributor wires are connected to individual spark-plugs having a 3/16 in. gap. Then the magneto is run 40 min. at 1500 r.p.m., with timing lever full advance and 10 min. at 3500 r.p.m., full advance, and 10 min. at 150 r.p.m., noting that it runs equally well during the last test in either advance or retard position.

During these runs the contact points should not spark or flame excessively. There should be no excessive noise or stray sparks detected about the magneto. The safety gap in the magneto should be 5/16 in. and should not spark at any of the speeds given. See that the shaft of the magneto turns freely at the end of the test, making sure to distinguish the magnetic pull from any binding of the rotor. Examine the breaker bar to see that it moves freely. See that the platinum points come together squarely, line up, and are free from burning or blackening. Check up the opening of the points and see that it is as specified by the manufacturer. See that the bumper is running evenly over the surface of the cam and that excessive wear is not noticeable on either cam or bumper. Make sure that the distributor gear turns freely and that the oil feeds in through the cup, reaching the bearing properly. Examine the distributor disk to see that there is no heavy carbon deposit and that brushes are running evenly over the surface of the disk. Reject the magnetos in which carbon brushes run only on one side and reject any magneto which fails on the above requirements or in which any part not mentioned shows excessive wear. The mechanical tests for one twelve-cylinder magneto are practically the same as those mentioned above, except it is first driven 40 min. at 3500 r.p.m., 10 min. at 4500 r.p.m., and 10 min. additional at 150 r.p.m. In addition to the foregoing running tests, the following is a sample of the general inspection to which the magneto should be subjected, this applying particularly to the four and six-cylinder magnetos. Observe the general appearance of the magneto exterior finish, marking off rotation, fitting of covers, breaker box, etc. See that the rotation and advance lever or any special features correspond with the customer's specifications. Check taper of shaft and location and size of keyway. See that the holes in the base conform to specifications as regards size and location, and that they are tapped perpendicular to the plane of the base. See that all screws and nuts are tight and lock washers in place and that no screws are missing from the breaker box. See that the breaker arm moves freely, that the platinum points line up and that the breaker arm does not strike the cam at any other point than the bumper. See that the end play in the field structure does not exceed 0.004 in. The advance lever should move freely and should not require more than three pounds suspended from the hole in the lever to advance or retard it fully. Try the carbon brush springs to see that the pressure is light. See that the breaker cover spring fits tightly.

AUTHOR'S CONCLUSION

In conclusion, the statement made in the first part of this paper may be reiterated. Mechanical defects and the failures due thereto form by far the largest part of magneto troubles.

The magneto manufacturer has been "up against" many difficult problems, not only in meeting requirements which have ranged all the way from a magneto for a sixteen-cylinder engine, this magneto producing two sparks for each cylinder (which would mean a 32-point distributor), to a good high-tension magneto for a farm engine, to cost about $3.50. Limitations both in dimensions and weight have been met. All things considered, the magneto is truly a wonderful piece of equipment.

Factory Inspection

By WALTER C. KEYS* (*Member of the Society*) CLEVELAND SECTION ADDRESS

INSPECTION as applied to manufacturing, and to the automotive industries in particular, may be said to mean the checking up of dimensions or specifications, or both. In practice it should and frequently does extend to the relation of parts, the assembling and the materials used, in order to insure the requisite accuracy and quality.

At the Chicago meeting in February we were told of a certain government inspector who rejected a bayonet that was 0.004 in. too narrow. That seemed to be an absolutely foolish use of authority, but preferable, on the whole, to another case which I happen to know about. The manager of a large automobile factory, wanting to make a good record on a new model, got into production at the end of July, and, against the better judgment of every one who knew what was being done, he shipped cars on which the varnish was so wet that every finger mark sank into it. That was an extreme in the other direction. We are all familiar with certain halfway practices that are quite as objectionable; for instance, the trick, because of a shortage in stock, of using materials that have been inspected and rejected.

Inspection is absolutely necessary, as we all know, because of errors which creep in during the long process of converting raw materials into finished products, and in addition to errors there may be the intention to "slip something over," since human action is less than 100 per cent efficient and honest.

By inspection only can we maintain the quality set up as standard under the general policy of a company, and unless there is some one person or some department in the plant whose business it is to watch the quality of workmanship, materials, finish, etc., the general quality of parts will fall off.

There are, of course, several kinds of inspection. Some of these will be applied to certain parts only of a vehicle or engine, while all may be required for certain other parts.

VISUAL INSPECTION

First in importance is, without doubt, visual inspection. That means really looking at a piece of work with intelligence, practical knowledge of workmanship, and full information as to specifications.

A few years ago I saw in the Morgan & Wright plant in Detroit an example of visual inspection that was amazing in its speed and facility. The men took tire casings, mounted them on rims and inflated them; then took the tires and whirled them around, somewhat as one would spin a coin on its edge. While the tires were spinning they were also turning circumferentially, thus enabling the inspector to see all parts of the tire casing in a very few seconds. Visual inspection is applied to forgings, castings, tubing, leather, upholstery and glass, and to the appearance of paint or linoleum.

Another kind of inspection is that of measuring. This is applied to practically all metal, wood and glass pieces, and to almost everything used in the automotive industry.

INSPECTION BY GAGING

A third test is gaging. Many different kinds of gages are made for testing intricate pieces to find out if certain essential dimensions have been maintained. In one of the large plants in Chicago they have one inspector to about ten employes, and every individual piece used must pass the required inspection. For example, a coil of wire must have the correct dimensions, the wire must be correct as to gage, the spool must be the correct size, the finished coil must show the proper resistance, and must not show any grounds, crosses or short-circuits. That is an unusual example of inspection, and is necessary there because of the enormous quantities of exactly similar materials made. At any time they can send out a piece or an assembly and know that it will interchange with the part it replaces. Plug, ring and snap gages are the types most commonly used. I have seen the rear half of an automobile body used to test the fit of rear fenders; if all fenders fit that body, and the body is known to be right, then all fenders will be right. The next problem is to keep production bodies like the first sample, and thus insure interchangeability of all bodies and fenders.

INSPECTION BY WEIGHING

Weighing is another kind of inspection. This is applied to flat-leaf springs, pistons, connecting-rods, etc.

Function inspection is applied to an assembly which may be purchased, as for example, a horn, headlamp, magneto or pump, and to lubricating oil. Then there are all sorts of special tests, such as putting air pressure into a casting to detect leaks, trying to break a piece at the weld, and running gasoline through the needle valve used in the carbureter, etc.

CHEMICAL ANALYSIS

Chemical analysis might be called a test, and in that connection I want to mention the importance of measuring the Brinell hardness after the quench as well as after the draw. The hardness is sometimes specified for government work. The test pieces specified in the S. A. E. Handbook are uniform and small, but with heavy, irregular forgings the temperatures given on the data sheets do not apply, and it is necessary to use the cut-and-try method to determine the temperatures which will give the required hardness after the quench and after the draw.

Inspection should be a help to production. The end in view is of first importance, not the mere working of a top-heavy system of red tape. The kind of inspection fixtures to be furnished for a part must be determined by the production contemplated. For a few pieces no fixtures will be needed at all, but for thousands and tens of thousands of the same part it will pay to make very elaborate fixtures.

The Chicago firm already referred to uses most clever appliances, made with the utmost accuracy, for testing. These are passed upon by the tool inspector and then used by the men actually handling the parts on the floor. The workmen and inspectors need know very little about the dimensions of the parts; the indicator on the testing apparatus is their guide.

I happen to know of a company which has built up an enormous industry along the line of using gages to produce interchangeable parts which fit together. Even

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today in Europe the idea of fitting parts together by hand is still prevalent. The point is that with highly skilled labor a better mechanism can be built than is generally produced by the use of manufacturing gages and inspection fixtures. Production, we all know, is far greater, and cost is much lower, under the latter method.

A three-cornered situation sometimes develops, in which both foremen and inspectors are delayed because the engineer has released something impracticable to make. This calls for decisive action on the part of the engineer, who must revise his designs or methods somewhat so as to get production.

I think that in at least 50 per cent of the plants manufacturing automotive products today inspection is independent of the manufacturing department. This is, without doubt, the best arrangement, since quality will be sacrificed in favor of quantity if the man who produces can also approve what he makes.

The quality in large factories is sometimes improved by sending to the foreman and inspectors a copy of the customer's report of his own inspection of the car he has just bought.

THE DISCUSSION

CAPT. C. F. CLEAVER (M. S. A. E.): It may be of interest to hear something about the work of British government inspectors. Of course, the general opinion is that we have a nice time; we drive the trucks around and go home. The work itself is interesting, however, because in addition to inspecting there is much of the human element in it. We have to keep after the manufacturer to get the goods, and to discriminate to a nicety on how much we can let go through and thus not interfere with factory work or deliveries. We never let anything pass that will interfere with proper working results. We have an official chart in five parts:

The Schedule, usually a fixed delivery, is a straight line.

Inspection, from which we get information as to the progress of work in the factory.

Shipments, finished articles from the factory. That line drops when we have to deal with the railroad companies.

Arrivals at port.

Shipments from port. The line drops, for we have to struggle for steamship accommodations. It takes a long time to get things through.

We have been running a year and a half, and can now see how inspection and final shipments have been converging.

People often wonder why officers are sent over here. There has been some talk of recommending young men direct from technical colleges for this work. That would be a great mistake, because we inspectors have to deal with the heads of firms, and young fellows do not know "what is in between." An interesting suggestion, and one that might be developed, is to make the head tester in a factory a high-priced man.

Another point I might make is this: A great deal of attention is paid to machining inspection, but not nearly enough to assembly inspection. It is difficult to make people understand the importance of the little things.

I was once on a truck in England from which one cotter pin had been omitted in the steering arm, and the arm came off. At another time one cotter pin was missing, and three good soldiers were killed. I know of one truck that I inspected which, after all, reached England without its reverse gear. Those were little parts, but we have to continuously impress the manufacturers with their importance. We get after them, and keep after them, but our work is not so much against them as with them. I have now inspected in a good many factories. Usually, they have never had government orders before, and they resent our being there.

We see the manufacturing process from the outside and from the inside, and I think we realize the importance of inspection far more than the man in the shop does.

CHAIRMAN W. R. STRICKLAND (M. S. A. E.): Mr. Wells, who has been in London for about three years, will tell us how our American trucks arrive there. No matter how careful the inspection is over here—single, double and triple inspection—there is still inspection on the other side.

M. R. WELLS: Inspection on the other side is, naturally, for the benefit of both customer and manufacturer. The British government maintains inspectors in the factories here, and I believe they should be held responsible for all ordinary tests and for everything not occurring during transit. I go even further, and claim that they should be held responsible for gear noises, etc., and that no complaints of that nature should be handled after the order has gone across the sea. I should certainly discourage any attempt to do repair work of that kind abroad, for good labor is now hard to get. All the best engineers and mechanics are in the army.

The final inspection by the customer comes after the trucks have been accepted by the agent. Particularly when shipments begin, I should say that the inspector should himself go over and test the first trucks for power, etc., under different conditions, and to get an idea of what he can expect from later deliveries. After that I certainly recommend that he leave details to the testers of the agents.

The best inspector I know of was a good practical man. He was well over the age limit, but he joined the army and was assigned to this work. He followed almost literally this suggestion that I have made, and I think I never saw him ride more than three trucks; yet while he was on the job there were fewer complaints of a practical nature than with a number of succeeding inspectors who rode each truck but did not have his practical knowledge.

PRECAUTIONS IN SHIPPING

The way trucks are shipped may be new to some. The truck, after test, has all the cushions, the lamps, skid chains, tools and equipment that go with it, boxed and bolted to the frame. Very few of the trucks are crated. All the boxes are numbered with the truck number, and show the order number, the consignee, etc. The way they are handled on the boats may be surprising. Sometimes they are shipped on the upper deck with a tarpaulin over them. In other cases they go into the hold, and, after being roped and tied down, coal or some other material is dumped on them. Sometimes they come out of the ship covered with molasses. We have found boxes of knitting machine needles in the under pan of cars at the docks. In loading on the boat they are likely to be picked up any way by the craneman, and that results in all sorts and kinds of trouble.

Errors in shipping methods should be corrected without delay by cable. The desirability of sealing is very important. When we got the first shipment of 43 trucks without seals immediately the question came up as to their condition internally. Seal all parts that might be tampered with—the oil-filling caps, breather caps, and other places where emery can be forced into the engine or transmission. Anything of that sort is sealed not

so much to prevent as to indicate whether there has been tampering. If a seal is broken we look further before the truck is run. Sealing also serves to locate responsibility for trouble when found. For instance, in one case the truck came with the battery box locked. The lock had not been tampered with, yet when the box was opened both wires were found cut off about five inches from the battery. If the box had not been sealed we should not have known where this was done.

On first shipments, one should check the carbureter, the nozzles, etc., for local conditions. Necessary instruction sheets should also be prepared and the parts described in local terms. We say piston pin, they call it a gudgeon pin; we say hand truck, they call it a hand trolley, etc.

Action of Salt Water

Salt water is the cause of much damage. I do not believe that any one who has not seen results can have a conception of what salt water will do. It is essential to instruct the factory on this point. Paint that is satisfactory for local work will not bear the crossing, and frames will rust. One of the first troubles experienced was on a batch of cars equipped with Bosch magnetos. They failed on the ignition, and upon investigating I found that practically all the safety-gap caps were short-circuited. I thought first of salt water, and boiled them; then I baked the porcelain, without success, and in the end we bought new safety caps. Later on, when we changed from the Bosch type, trouble occurred again, but this time the coils were short-circuited. They had been made with a cover, which normally was an insulator, but salt water got into them. The switches were opened, and found full of salt. Electrolytic action on the die castings was apparent and the brass contact buttons were often eaten away, or covered with a layer of copper that could be snapped off with a knife. The factory should protect the coils during transit.

Some of the trucks gave trouble after delivery. During a damp, cold night the slight salt layer on the distributor, which was dry when they reached us, would draw moisture, and the high-tension current would spread over the distributor. In some cases this started such a short-circuit that the bakelite had become carbonized, and little grooves were burned into it.

The effect of salt water on carbureters is another thing to be watched. The needle valves give trouble occasionally after a very bad trip in which water has collected in the float chamber, where there are two different metals, the float being copper and the needle valve steel. I have seen needle valves eaten in two by the electrolytic action. I have seen the air intakes of the carbureter entirely blocked off by solid salt. It is hard to understand how so much could collect there.

The leather belts have to be looked after. Of course, the salt gets into and starts to open the glued joints. In some cases the belts have been pried in two. Glued parts, such as steering wheels, made trouble. Floorboards swell, naturally, and allowance must be made for clearance. Water got into the boxes of spare parts, even when surrounded by waterproof paper, until a change was made in the design of the cover and waterproof paper used outside.

Salt gets in and rusts the joints, steering gears, etc. I recall one case where a steering-gear housing, which had been in use for a week or so before being shipped, tightened up and had to be taken apart some time after delivery. In order to push the shaft out of the bushing a big sledge, used by a husky blacksmith, was necessary.

The factories do not use enough grease. It is well to pack cavities full, for sometimes there will be salt water even in the hub caps.

In England I found the average drivers riding the clutch pedals. That put an extra burden on the clutch collar, and made trouble which we had not had over here. As long as there was grease on these clutch collars they would not cut, but owing to a feature in design the clutch collar was robbed of its lubricant when constantly ridden, as that kept the collar hot and melted the grease. A slight change in grease grooves overcame this difficulty.

The damage due to handling in transit usually comes in waves or epidemics. A new loader may dump the trucks so as to bend the frame members; another may bend the steering columns; another will bump his loads on the hatch and break dashes and seats. Grease cups, safe enough here, were too much exposed in transit, and had to be shipped in boxes and installed later. Another gang would place a tow-line so as to break off certain grease cups. Starting cranks or brackets would be broken by some labor gangs. It was sometimes difficult to determine quickly just where the damage was being done, and perhaps by the time this information could be obtained the man at fault had been replaced by another who would probably start some new trouble.

We have had to inspect for stolen parts, tools, locks, etc., also. Brass caps were stolen and sold as scrap. One thing surprising was that the leather boots would be stolen for the lacings.

At other times these epidemics would pass through the factories. Some faults would not show up under the conditions of inspection in this country. The inspector on the other side has to note not only what is wrong but why it has gone wrong. If a bearing failed, it was likely to be due to a man new on assembling at the factory. Broken chain links or links of a different pitch should be discovered at the factory, but sometimes got through

Spare parts have to be watched and examined the same as the completed truck, and here again the most important thing is the method of packing. We must assume that the factory inspects for dimensions, quality of the goods, etc.

Red tape has to be taken into consideration in the army, and cooperation among inspectors, factories and engineering departments is absolutely essential, in a way not realized until one is in a foreign country.

A MEMBER: I have heard that in crossing the ocean the salt air is apt to affect transmission gears even when submerged in oil or grease.

MR. WELLS: That brings up an interesting point. We assume that all parts of a transmission are thoroughly covered with oil, and yet in one make we always find the head of a certain bolt with no oil on it. In every case salt air gets in and rusts the head of that particular bolt.

E. T. BIRDSALL (M. S. A. E.): In the early days we had nothing like the trouble Mr. Wells has described. We brought over three or four hundred cars in crates, but without paper. They were touring cars with bodies, and some chassis, and the factories did not always take out the gasoline. We used to uncrate them, crank them, and run them uptown. Our chief trouble then was that the men who unpacked them used crowbars to take the crates off, and unless one gave them a couple of dollars and the crate, the crowbar would get through the finish. We had no trouble with rust or salt water, as we carried them in the hold and not on deck.

Tractor Experiences In Illinois

By Arnold P. Yerkes and L. M. Church

THE GAS TRACTOR has proved valuable under many conditions, although it is still in process of development. The experience of more than 600 Illinois tractor owners has been set forth in Farmers' Bulletin 963, U. S. Department of Agriculture. In this are discussed the advantages and disadvantages of the tractor, size of machine required, original cost, cost of operating, length of life, kind, quantity, and quality of work performed. Extracts from it are given below.

PROBABLY the most significant difference between the reports received from tractor owners in 1917-18 and those received in 1916 is the much larger percentage of men who report that the tractor has proved a profitable investment. In 1916 less than 80 per cent while in 1917-18, 90 per cent, or 9 out of 10 men, made such reports. This is partly due to improvements in the tractor, and partly, of course, to the increased prices commanded by both farm products and farm labor during the past year. In this connection, however, it should also be noted that while at the beginning of 1916 a considerable number of the large old-model tractors were still in use, by the end of 1917 practically all of these had been discarded, and the reports on which this summary are based deal almost without exception with the small or medium-sized tractors developed during the last three or four years, which not only cost less in the first place, but give every indication of having a longer life and lower repair charges than the older models.

Another significant difference between 1918 and 1916 is the increase in the percentage of three-plow outfits and the decrease in the percentage of two-plow outfits in use, which is in keeping with the opinions of tractor owners set forth in Farmers' Bulletin 719, to the effect that the two-plow outfit is not large enough for the average corn-belt farm, and that the three-plow or four-plow machines are better adapted to conditions in Illinois.

Nearly three-fourths of all the tractors in Illinois on which reports were received in 1917-18 were pulling three plows, while more than three times as many two-plow as four-plow machines were in use.

Size of Farm and Tractor

Though the introduction of an improved farm machine may be expected to reduce the man labor required for farm operations, thus permitting one man to accomplish more work and so farm more land than with the older methods, a farm business must be of sufficient size to permit the economical use of an improved machine in order to justify the necessary investment. That is, many small farms must either use the old methods or hire a modern outfit, because the small amount of work to be done each year does not warrant owning the machine.

Among the more important facts disclosed by a study of the use of the tractor for farm work are those relating to the increase in the acreage which can be farmed by one man when a tractor is used in connection with horses, over that farmed with horses alone. Approximately one-third of all the Illinois farmers reporting increased the acreage they were farming after purchasing a machine, the percentage of men so doing being slightly higher in the group reporting the tractor profitable. The percentage of the entire number of tractor owners who have enlarged their farms is significant, for whereas there has been a tendency for the size of corn-belt farms to increase in recent years, the increase among farms in general is not nearly as pronounced as in the case of farms on which tractors are used.

It is doubtless as a result of the more general use of the three and four-plow machines, and hence a better acquaintance on the part of farmers with these sizes, that 76 per cent of all owners reporting recommend the three-plow machines, while 13 per cent favor the four-plow outfit, and only 11 per cent advise a two-plow rig, whereas, at the time the data on which Farmers' Bulletin 719 was based were collected (1916), a somewhat greater percentage of owners recommended the four-plow than the three-plow outfit, with 13 per cent advising the two-plow rig. At present there seems to be no doubt that the three-plow size is the general favorite for corn-belt conditions, whereas the four-plow is more generally preferred than the two-plow size.

Even on farms of comparatively small size the three-plow tractor is recommended by the largest percentage of owners. This, taken with the other facts, seems to indicate that the two-plow tractor does not increase sufficiently the amount of work which one man can do, hence does not possess, except to a slight degree, the greatest advantage of tractors in general, namely, timeliness in performing farm operations through much more rapid work than is possible with horses. Moreover, a two-plow tractor does not ordinarily develop enough power to make it suitable for operating grain separators and ensilage cutters, tasks for which power is required on the average corn-belt farm. It happens not infrequently that the owner of a two-plow tractor has to hire an engine with slightly more power to do his belt work, so it is not to be wondered at that in case he were buying another machine he would select one with more power.

The question as to the smallest size of farm on which a tractor can be expected to prove profitable is one often asked and one that has been much discussed. Certainly no more reliable opinion on this point could be obtained than the average of the estimates of a large number of tractor owners. In the opinion of these men the minimum number of acres on which two, three, or four-plow outfits may be expected to prove profitable are 130, 170, and 210 acres, respectively.

Attention is called especially to the fact that these figures represent the *smallest* size of farm for which these tractors should be purchased, in the opinion of men who have had experience with them, and not the size on which they can be used most profitably. A farmer who is contemplating the purchase of a tractor and whose farm is smaller than the acreages above given should consider carefully before acting contrary to the opinions of experienced men.

The average sizes of the farms reporting on which two, three or four-plow tractors are in actual use are considerably above the minimum figures given above, being 180, 250 and 300 acres, respectively.

The three and four-plow sizes seem to meet best the tractor requirements of the average farm in Illinois; they enable plowing to be performed much more rapidly than is usual when horses are employed. The man labor is also reduced when using these sizes of tractors, as one man attends to three or four plows at one time, instead of only two, as is ordinarily the case where horses are used. (Where modern self-lifting gang plows are used, one man ordinarily handles the entire outfit in plowing, no matter what size gang is used.) Furthermore, the four-plow size of tractor is generally powerful enough to operate practically all of the machines which are commonly found on the average farm, including the ensilage cutter and the medium-sized grain separator. At the same time it is not so expensive in operation as to prohibit its use for many odd jobs which do not demand a great deal of power.

Cost of Tractor Outfit

The price which a farmer can afford to pay for a tractor for use on his farm depends upon a number of factors, such as the amount and value of the work which the machine will perform annually, the value of the horses which it will displace, the value of the man labor saved, and the amount of increased returns which reasonably may be expected from its use.

The prices for both tractors and the implements for use with them have been considerably increased during the last two years, owing to the advances in costs of both labor and materials required to produce them. The prices paid for the three sizes most commonly bought during 1917 on the Illinois farms reporting averaged about $800 for the two-plow, $1,100 for the three-plow and $1,400 for the four-plow machine, while the prices for the plows for use with them averaged about $115, $165 and $235, respectively. In all cases the prices, of course, varied considerably according to the make and quality of the machines. At the beginning of 1918 there was a further general and substantial increase in prices.

Life of the Tractor

It is obviously impossible to determine definitely the probable life of the latest model tractors, since none of them has been worn out, but the nearest approximation to the actual figure would unquestionably be the average of the estimates given by a large number of men who had used them for a season or two. Tractor owners were asked for an opinion as to the number of years their own particular machines would give satisfactory service, and also to give an estimate of the average life of farm tractors. The replies to these questions showed a tendency on the part of men who reported the tractor as having been profitable to estimate that their own machines would last somewhat longer than the average machine. On the other hand, men reporting them unprofitable usually gave the probable life of their machines as less than their estimate of the average life of tractors in general. The answers to both questions, however, averaged very nearly the same, being eight and seven and one-half years, respectively.

Of course, these averages cannot be regarded as being absolutely accurate, but certainly they should be as nearly accurate as any figures which could be obtained in any other manner at the present time. As a matter of fact there would probably be a tendency on the part of tractor owners to overestimate somewhat. It is not believed, however, that a prospective purchaser of a tractor should expect for his outfit a longer life than seven and one-half seasons, and he would be on the safe side if he counted on a somewhat shorter period of service when calculating the probable value of a tractor for his work.

Days Used Annually

The life of a tractor cannot be expressed definitely in terms of years, since the number of years it will last will depend upon the amount of work done each year; that is, the number of days or hours it is used. This varies on different farms, according to size, type and system followed, the average for tractors in Illinois being 45 days per year.

While at first glance this may appear low, when it is remembered that on farms where horses do all the work they are used on an average of only about 100 days annually, it will be seen that where both horses and tractor are used, even though the number of horses is somewhat reduced, the machine need not be expected to have employment for as many days annually as did the horses. The horses kept will still do some of the work, which will, of course, decrease the amount to be done by the tractor. A considerable percentage of the 100 days' work done by horses represents odd jobs for which the tractor cannot be used to advantage. Even if the machine were to do all the work formerly done by the horses, it would not normally be employed 100 days per year, inasmuch as it does the work more rapidly.

Practically all farm operations must be carried on within limited periods, and between these seasons there will often be no field work that the tractor can do, either on the home farm or for neighbors. The fact that weather and soil conditions are such as to permit field work with a tractor does not necessarily mean that there is such work to be done. Farm management plays an important part in organizing the farm so as to provide profitable employment for the tractor during as many days as possible. Such organization involves the planning of a crop rotation which will furnish a large amount of work which it can do, the elimination of as many horses as desirable, and the distribution of the work over a long period. However, the rotation should include only such crops as can be grown profitably in that particular section.

Expense for Repairs

Of 140 tractor owners in Illinois who had used their outfits one season or less (average age 9 months), 48 reported that they had spent nothing for repairs. The others had repair bills varying from a few cents to a hundred dollars or more, the average being $22, mak-

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ing the average repairs for the entire group about $15. Comparatively few machines go through their second season without repair charges. The average repairs for 158 Illinois outfits between the ages of 13 and 24 months (average age 20 months) was $39. For 34 machines between the ages of 25 and 36 months (average age 32 months), the average repairs amounted to $79.

It is impossible at present to state definitely just what effect the size of tractor has upon the repair bills. The figures thus far obtained would seem to indicate that the percentage of the first cost required annually for repairs is somewhat lower for the four-plow size than for the smaller outfits, but this may be due to the fact that there are more cheaply constructed and low-priced outfits among the smaller sizes than among the four-plow machines. It is impossible as yet to make any definite statement as to the annual repairs required by high-priced machines as compared with lower-priced ones of the same capacity. The figures seem to indicate that repairs are somewhat lower for the high-priced machines, but there is not enough difference to justify a positive statement to this effect.

The figures given would indicate an annual repair charge during the first three years of a tractor's life of about 3 per cent of the first cost, but this would undoubtedly increase during the latter years of its life, as is the case with most other machines. It would not seem safe to expect the cost of repairs for a tractor to average less than that for other farm machines, which is a little over 4 per cent, and it is not improbable that it will amount to slightly more than this. In figuring the repair costs to be charged against each day of use or acre plowed, the average annual charge has been taken as 4 per cent of the first cost.

Plowing Done per Day

The number of acres covered per day by a plow drawn by a tractor is usually slightly greater than that covered by the same sized horse-drawn plow. The acreage covered by two different machines, each pulling the same number of plow bottoms, often varies considerably, because they travel at different speeds, are in different kinds of soil and plowing different lengths of furrows. Theoretically a 14-in. plow when drawn by a tractor should cover about 3 acres in an ordinary working day of 10 hr., as the average plowing speed is slightly more than 2 m.p.h. This will hold true in actual practice when the plowing conditions are favorable, provided the outfit does not give trouble. That is, a two-plow machine should plow 6 acres and a ten-plow outfit 30 acres per day, provided both travel at the average rate of speed and are kept moving. However, where trash is to be turned under which frequently clogs the plows, each plow drawn by a large tractor will cover much less ground in a day than one drawn by a small outfit, since the delays will naturally be in proportion to the number of plows pulled. A delay on account of one plow on a two-plow outfit stops only one other plow, while on a ten-plow rig, for example, it stops nine other plows.

In view of these facts it is apparent that when plowing under unfavorable conditions large gang plows do not cover as much ground per day per plow as the smaller ones. However, one man accomplishes considerably more work with the large outfits, even under such conditions.

According to the figures furnished by tractor owners in Illinois the area covered per day (10 net working hours) in plowing with the tractors most commonly used is 6½, 8¾ and 10 acres for the two, three and four-plow outfits, respectively. These figures for the two-plow and four-plow outfits correspond closely with the averages shown in Farmers' Bulletin 719 for the same sizes of tractor, while the average acreage covered by the three-plow rigs shows an increase of one-half acre per day. This is doubtless due to the placing on the market of a large number of three-plow outfits of slightly greater power, and therefore larger capacity per day, than the three-plow machines in use when the data for Farmers' Bulletin 719 were obtained.

Many tractor owners require their outfits to pull one more plow than they are rated to handle. Under such a load the outfit does not cover as much ground as would be covered by a machine built to pull that number of plows. Three plows behind a two-plow tractor will cover only a little more ground, as a rule, than will the two-plows, because the tractor usually will travel a little more slowly, partly because the engine is overloaded and does not maintain its proper speed, and partly because the drive-wheels will slip more than usual with a load heavier than the machine was designed to pull. As a consequence delays on account of small holes or slight grades will be more common, as will also mechanical difficulties.

The reports of a number of men who were thus overloading their machines were tabulated and compared with the results obtained by other men who owned the same make and size of tractor, but who were requiring their machines to pull only their normal loads. This comparison showed that the repairs on the overloaded tractors were considerably higher, more time was lost per day with these outfits, and the estimated life of the overloaded tractors was considerably less than for the machines pulling normal loads. At the same time the increase in ground plowed amounted to only about 1¼ acres per day; that is, the additional plow covered about one-half as much ground in a day as did each of the two plows which constituted a normal load. The gasoline consumption per acre averaged somewhat lower for the overloaded machines, as would naturally be expected, since the tractor would not have to travel so far to plow an acre. However, the depth plowed was not so great, and it is reasonable to suppose that the plowing conditions were generally favorable or the third plow would not have been tried. The increased acreage per day and the slight saving in fuel together would not offset the increased repairs and the value of the time wasted from trouble with the outfit. Overloading a tractor is inexcusable save in exceptional cases where speed in completing a job is of the utmost importance. If such speed is required regularly the work could be done more cheaply and satisfactorily with a larger outfit.

The acreage covered per day at field operations other than plowing will vary, of course, with the width of the implement pulled, and this in turn will depend upon the relative draft. It is therefore impossible to give for such operations average figures which would be of value. In harrowing or disking, for example, the width of the implement pulled will depend upon the adjustment of the disks or harrow teeth and the depth of the ground being worked. The nature of the soil will also have an influence. The speed of the tractor ordinarily will not be quite as great in soft ground as where the machine has a firm footing, because of the greater slippage of the wheels. On the whole, not so much time is lost on account of clogging or other obstructions when harrowing and disking as when plowing.

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The approximate acreage covered in a day of 10 hr. with implements of different widths can be determined easily by allowing about 2 acres per day for each foot of the implement's width where the outfit is working on soft ground. Where it has a good footing it may be safe to allow 2½ acres for each foot of the implement's width. The acreage covered, of course, will vary with different machines, owing to the different speeds, but the figures given are based on a speed of 2 m.p.h., with an allowance for time lost in turning and the slight overlapping which occurs to a slightly greater extent in most other field operations than in plowing.

By far the largest proportion of the work done by tractors is in plowing and preparing the seed bed and in belt work. While they are used for a number of odd jobs at different times, these represent an insignificant portion of the total work. Hauling, which usually occupies farm horses for several days annually, is not commonly undertaken with the tractor, and in most cases where it has been tried it has been found less satisfactory and more expensive than horses. To make an economical load for the tractor it is necessary to have several heavily loaded wagons; this is an unwieldy outfit in turning corners and in getting in and out of loading and unloading places in most towns and villages. Other objections to the use of the tractor for hauling advanced by men who have tried it are the heavy wear and tear on both tractor and wagons on hard roads, expense on the unloaded return trip almost as great as when loaded, and difficulty in handling heavy loads on grades. It is not surprising, therefore, that only about 20 per cent of tractor owners report doing hauling with their outfits and that on the whole it represents less than 4 per cent of the work done by the tractor.

Cost of Operation

The cost of performing farm operations with the tractor is made up of four main factors, namely, operating expenses (including fuel, oil and grease), repairs, depreciation and cost of man labor. In addition there will be some less important charges, such as interest on the investment, cost of housing and time spent in caring for the outfit other than that for repair work.

In order to give the prospective purchaser an idea of the average cost of using a tractor, the following figures for the sizes most commonly used have been compiled. From the facts given it is believed that a farmer can approximate the costs for any other size in which he may be interested.

Fuel Cost—The average quantity of fuel consumed per acre in plowing, for all tractors, on Illinois farms reporting is 2½ gallons. This figure does not vary materially for the different-sized outfits as long as each pulls its normal load. It is possible, however, to reduce the fuel consumption somewhat by overloading the tractor; that is, adding one more plow bottom than the machine is intended to pull. This, as pointed out already, reduces the distance the machine must travel to plow an acre; and, consequently, results in a slight saving of fuel. The saving is not in proportion to the actual distance traveled, however, since with the overload there is much more slippage of the wheels and consequent loss of power.

There is some slight difference in the fuel consumption between different makes of machines, and also usually a slightly lower consumption in some makes of tractors when gasoline is used instead of kerosene. These differences, however, do not usually amount to a great deal, and for most purposes the figure of 2½ gal. of either gasoline or kerosene per acre of plowing will be as nearly accurate as any that can be used for an average.

The investigation shows that less difficulty is being encountered by owners of kerosene tractors in burning the lower grade of fuel than was indicated in 1916. Slightly more than 50 per cent of the tractors on the Illinois farms reporting are operating on kerosene, and when the machines have been especially designed to burn this fuel the results are apparently satisfactory, particularly in view of the present price of kerosene as compared with gasoline, the former costing only about one-half as much as gasoline. However, the greater ease in operating on gasoline, and the somewhat greater certainty of steady operation, are sufficient to cause many men to prefer this fuel. The fuel consumption, of course, varies considerably, even with the same make of machine and under practically the same conditions, when driven by different operators, as a proficient operator can make such adjustments as will reduce the fuel consumption to the minimum, whereas an inefficient operator will frequently run the outfit in such a manner as to increase unduly the amount of fuel used.

In this case, as in others, a prospective purchaser is not safe in assuming that he can obtain better results than the average, although of course he should endeavor to do so. The average price paid for gasoline by the Illinois tractor owners in 1917 was about 20 cents per gallon, and for kerosene slightly less than 10 cents per gallon. With these prices, therefore, the fuel cost per acre for plowing with the tractor averaged about 25 cents with kerosene and 50 cents with gasoline, not making any allowance for warming up the kerosene engine with gasoline. All kerosene tractors start and warm up on gasoline, but the quantity used for this purpose varies greatly with different makes and with different operators. The quantity of gasoline required for this purpose is in most cases less than 1 gal. per day, and the extra cost for gasoline will usually not exceed 10 cents per day, and should seldom be more than 1 cent per acre plowed.

Lubricating Oils and Grease—The quantity of lubricating oil used per acre with different outfits showed a much greater variation than the fuel required. Some men reported using nearly a gallon of lubricating oil per acre, while many reported less than 1 pt. per acre. The quantity used will, of course, vary somewhat with the different makes of machines, but the greatest variation will be due to the idea of the operator as to the quantity with which the engine should be supplied.

It is usually false economy to cut the quantity of oil down too low, but on the other hand it is easy to use more than is necessary. The average quantity of oil per acre used in plowing, for all tractors reported from Illinois, was about three-fifths of a quart. With oil at 35 cents per gallon (the average price paid for it), this would amount to 5¼ cents per acre. The kind of fuel used does not seem to make any decided difference in the quantity of lubricating oil required.

The quantity of grease, or "hard oil," used also varies widely with different machines and operators. No attempt to obtain definite figures on this point was made, as it is of such minor importance that few farmers pay much attention to the quantity used. It is not believed that the consumption will amount to 1 lb. per day on the average, and the cost is usually in the neighborhood of 10 cents per pound, thus making the cost of this item amount in most cases to less than 2

cents per acre. At any rate, 2 cents per acre would be a reasonable figure.

Based on the figures given above for the Illinois farms reporting, the average cost per acre plowed for gasoline, oil and grease is about 57¼ cents where gasoline is used, and 32¼ cents where kerosene is used.

Repair Charges—Assuming the average annual repair charge as 4 per cent of the first cost, and the days used annually as 45, the average repair charge per day for the two, three and four-plow outfits of average price would be 71 cents, 98 cents and $1.24 per day, respectively. For the average acreage covered with these different-sized rigs, the repair charge per acre would therefore be 11, 11 and 12 cents, respectively.

Depreciation—Assuming the average life of a tractor to be 7½ years, the average annual depreciation on the two, three and four-plow outfits will be $106.67, $146.67 and $186.67, respectively. The daily charge, therefore, based on 45 working days per year, will be $2.37, $3.26 and $4.15, respectively.

The depreciation cost per acre, based on the average acreage plowed by the different-sized outfits, will be 36 cents, 37 cents and 42 cents, respectively. From these figures it will be seen that the depreciation charge is one of the largest items which go to make up the total cost of performing work with the tractor; yet it is one many people ignore entirely when figuring tractor costs. In this case, too, a long life has been used, which makes the depreciation somewhat lower than it would be altogether safe to count upon.

The cause of the depreciation cost for the four-plow machines being so much higher per acre than that for the smaller rigs is that the four-plow machines in use up to the present time have cost more in proportion to relative working capacity than the two-plow and three-plow rigs, owing partly to the fact that the smaller sizes have been manufactured in larger quantities, thus reducing the cost of production, and partly to the fact, stated elsewhere, that fewer low-priced machines have been produced in the four-plow size. This difference undoubtedly will decrease with increased production of the four-plow outfits.

Man Labor—Comparatively few of the Illinois tractor owners reporting hire operators, and in cases where the machine is operated by hired help the wages paid vary widely. Some men intrust their machines to ordinary hired hands at comparatively low wages, while others attempt to secure first-class operators and are willing to pay fairly high wages to secure thoroughly competent men.

To ascertain the cost per acre for man labor in plowing with a tractor, in order to round out these cost figures, the cost for man labor has been placed at $3 per day. This is about the actual cost for operators to many corn-belt farmers when cost of board is included. Using this figure, the cost per acre for man labor with the two, three and four-plow outfits, based on the average acreage given, would be 46 cents, 34 cents and 30 cents, respectively.

Interest Charge on a tractor is a fixed annual charge, and the interest cost per unit of work will vary with the number of days the tractor is used, decreasing as the number of days used increases. Figuring interest at 6 per cent on the average investment (one-half the first cost) for the different-sized tractors, and assuming the average number of days used annually to be 45, the average interest charge per day for the two, three, and four-plow outfits will be 53, 73 and 93 cents respectively.

The interest cost per acre, based on the average acreage covered by the different-sized rigs, would therefore be 8, 8 and 9 cents, respectively. The fact that the acreage covered per day by the four-plow outfit does not increase in proportion to its cost makes the interest charge per acre for this size higher than for either the two-plow or three-plow tractor. The increased acreage plowed per day by the three-plow rig as compared with the two-plow offsets the increased interest charge due to higher price. It should be borne in mind, however, that the number of days used annually will cause a variation in the interest charge per unit of work.

TABLE I—APPROXIMATE COST OF OPERATING TRACTORS

Size of Tractor	Total		Fuel		Oil	Grease	Repairs	Depreciation	Man Labor	Interest
	Gasoline Tractor	Kerosene Tractor	Gasoline	Kerosene						
2-plow..	$1.58¼	$1.33¼	$0.50	$0.25	$0.05¼	$0.02	$0.11	$0.36	$0.46	$0.08
3-plow..	1.47½	1.22¼	0.50	0.25	0.05¼	0.02	0.11	0.37	0.34	0.08
4-plow..	1.50½	1.25¼	0.50	0.25	0.05¼	0.02	0.12	0.42	0.30	0.09

Total Cost per Acre—The approximate total cost for plowing an acre with a tractor under normal prewar conditions, as calculated from the figures previously given would be as shown in Table I. The cost of housing the outfit and other minor overhead charges, such as taxes, insurance, etc., are not included in the table. It does give the approximate cost of plowing an acre with two, three and four-plow tractors, based on average cost of $800, $1,100 and $1,400, respectively, and a life of 7½ years of 45 working days per year.

From the figures given above it will be an easy matter to arrive at relative costs for other operations with the tractor. For all field operations the daily charges for interest, depreciation, and man labor will, of course, be about the same, but must be divided by the acreage covered by the implement used. This acreage will vary with different implements. The fuel and oil charge will be the same for a 10-hr. day in other field operations as in plowing, provided the tractor is loaded to the same extent. This, however, is frequently not the case. If a comparatively light load is drawn, the fuel and oil consumption will be somewhat reduced, but not in proportion to the load. For stationary work, if the engine is working to full capacity, the fuel and oil charges will be approximately the same as for a day's work in plowing, but no grease will be used on most machines. This, however, would be only a small item.

From the figures given under the cost of operation, it will be noted that the cost of doing plowing or other field operations with a tractor is approximately the same as with horses except for the item of man labor. This will average lower with the tractor than where horses are used, assuming wages to be the same in each case.

The advantage of the tractor, therefore, like that of most other improved farm machines, lies not so much in the reduction of the cost of performing a unit of work as in the fact that it permits one man to do considerably more work within a given period of time. This has been true of practically all improved farm machines, even of the grain binder, which is generally considered as one of the greatest agricultural inventions of the century, which did not, contrary, perhaps,

to general opinion, decrease the cost of harvesting wheat to any considerable extent, but did increase about eightfold the acreage that one man could handle.

Quality of Work

The quality of work done in plowing does not depend so much upon the tractor as upon the plow and its adjustment. Under average conditions, the work done by most engine gang plows when properly adjusted is fully equal, and often superior, to the work done by either a walking or gang plow drawn by horses and operated by a skilful plowman. If a job of plowing where a tractor is used is not satisfactory, it is not usually the fault of the tractor but of the plow, or, more probably, it is due to misadjustment of the plows. Of course, in fields with obstructions and sharp angles, the tractor may be responsible for poor work because of its clumsiness, but under most conditions the plows and the operator determine the quality of the work done. The tractor's part is to furnish the power to pull the plows.

This point should be kept in mind by farmers who select their tractors by visiting demonstrations of different makes of outfits. The quality of the work done by different machines should be of value in selecting a good *gang plow*, but it is practically worthless in determining the value of the different tractors. It is quite possible that a tractor of very inferior quality may be pulling a good gang plow, well adjusted, and doing much better work than an outfit of first-class quality which is pulling a poor plow or one that is out of adjustment.

The average depth of plowing done with tractors by the Illinois farmers who furnished data is slightly less than 7 inches. The average depth they had previously plowed with horses was about 5½ inches. While this deeper plowing is ordinarily considered to indicate a better quality of work, it does not appear to have had any marked effect on the crop yields.

The quality of disking, or other work on plowed land, will, of course, as with plowing, depend largely upon the implement drawn and the skill of the operator. The question of packing the soil is usually more important in connection with work on plowed land than in plowing, but that this is not a serious drawback with modern tractors in Illinois is indicated by the fact that 86 per cent of Illinois tractor owners reporting say that their tractors are satisfactory for use on plowed land.

Operating Requirements—In view of the fact that difficulty in operation is mentioned by tractor owners as the principal disadvantage of the tractor, it seems pertiment to state that although any man of ordinary ability can operate and care for a gas tractor satisfactorily after a little study and experience, it is decidedly unwise for him to undertake to gain the necessary experience by experimenting with his own machine. In most cases he can obtain the experience more cheaply elsewhere. Experience in running stationary engines or automobiles, while of some value, is not enough. The mere starting of the engine, changing of gears, and stopping, are simple matters, and any farmer can quickly learn to do these, but the important thing is the ability to detect trouble the minute it begins to develop and to be able to remedy it promptly instead of allowing it to run along until an expensive delay results.

Some tractor manufacturers offer to give purchasers of their machines thorough instruction at a reasonable cost. Purchasers of farm tractors should avail themselves of the opportunities thus offered to obtain a training in the use of the particular machine they will be called upon to operate.

Evidence of Reliability—Of more than 300 tractor owners in Illinois 54 per cent reported that their outfits were not disabled a single day when needed during the past season. Of the remaining 46 per cent the average number of days their tractors were out of commission when needed was five. This average, however, did not include one man who stated that his machine was out of commission about half the time.

The reports of tractor owners indicate that with a careful and proficient operator a gas tractor is a dependable source of power. Occasional slight delays will probably be encountered, but serious ones will be exceptional, whereas with a careless or incompetent operator expensive delays are apt to be frequent.

Of the tractors owned by Illinois farmers reporting, about 90 per cent are operated by the owner or some member of his family, the best results usually being obtained by this class of operators. Thirty-six per cent of Illinois owners reported no time lost in the field on account of trouble with the outfit. This probably means that the time lost was not worth mentioning. Most men do not consider it trouble so long as they know at once the cause of stoppage or other irregularity in the engine's operation, and are able to remedy it promptly. The average time lost per day by the 64 per cent reporting trouble is a little over three-quarters of an hour.

GRAPHICAL REPRESENTATION OF FORMULAS

In the September issue of the JOURNAL (see page 224) was reprinted a paper presented by F. Leigh Martineau (M. S. A. E.) before the Institution of Automobile Engineers in England. This paper was given by the author in order to call the attention of British engineers to the immense saving in labor possible by the use of "monograms," with which many routine calculations required of engineers can be quickly and accurately made.

The paper was, of course, written with special reference to British practice. Since it was printed in THE JOURNAL, however, the author has called attention to the fact that the subject had already been introduced in this country and that monograms, or alignment diagrams, are now in use here for many purposes. Mr. Martineau also states that the method he describes in dealing with formulas was given an excellent treatment from a theoretical point of view in a book written by Prof. John B. Peddle (M. S. A. E.), entitled "The Construction of Graphical Charts." (McGraw-Hill Book Company, 1910.)

The charts given in Mr. Martineau's paper have been published full size on 8 by 11-in. cards by the Institution of Automobile Engineers, and complete sets are available for $6.50 each. These are now being supplied to a number of large companies in England, and can be obtained by members of the Society in this country from Mr. Basil H. Joy, Secretary of the Institution of Automobile Engineers, 28 Victoria St., Westminster, London, S. W. 1, England.

Airplane Performance Determined by Engine Performance

By G. B. Upton* (*Non-Member*)

WE ARE all familiar with the fact that an airplane has a maximum speed corresponding to full power operation, and a minimum speed below which it cannot fly for lack of enough lift to maintain itself in the air. What these speeds are, and their relation to each other, depends on the design of the plane, the power available, and the loading, which is made up of weight of plane, weight of engine, accessories and fuel, and "useful weight" of aviator, passengers and whatever they take with them. Both the maximum and the minimum speeds here refer to horizontal flight at or near the ground level.

The ratio of the maximum to the minimum speed may be taken as a partial measure of the maneuvering and climbing ability of the plane. The margin or excess of power available at full throttle, over that required for the slowest sustained flight, is evidently the power that may be applied to climbing or maneuvering. If we load a plane too heavily, either with machinery or with "useful" load, the minimum speed will approach the maximum, and the plane will lose its power to climb. On the other hand, we may pare down on engine weight and on available power, by using a smaller engine, and thus overdo the business by reducing the maximum speed faster than the minimum speed, and ultimately lose climbing ability from lack of power. Obviously we need for good climbing power a careful adjustment of engine to plane, as well as the lowest possible weight of engine for a given power, and lowest weight and air resistance of plane for a given lifting ability.

When planes are built for war purposes a high rate of climbing and a high maximum attainable altitude or "ceiling" become of extreme importance. It is perhaps not realized by the non-engineering public that each plane has a limiting altitude beyond which it is unable to go. It will be readily appreciated that a plane with a ceiling of 25,000 ft. has a fighting advantage over one with a 20,000-ft. ceiling.

While the ceiling is controlled in part by the plane and engine, it is really largely determined by the atmosphere itself. The pressure of the atmosphere decreases rapidly with altitude, and temperature also decreases both changing the density of the air. The resultant changes are about as shown in Table I. At 20,000-ft. altitude the air is only half as dense as at sea level.

The change in density of the air affects the action of both plane and engine. The lifting power of a plane, at a constant angle of incidence, varies as the product of density of air and square of the velocity of the plane. Hence the minimum speed of the plane, for horizontal flight, increases with decrease of density. For constant lift δV^2 must be constant, or V must vary as $\frac{1}{\sqrt{\delta}}$. The last column of Table I then shows how the minimum speed of a plane for sustained horizontal flight increases with altitude. The power required to drive the plane under these conditions varies as δV^3, or as $\delta\left(\frac{1}{\sqrt{\delta}}\right)^3$, which works out to $\frac{1}{\sqrt{\delta}}$ again.

Table I—Density of Atmosphere at Various Altitudes

Altitude, Ft.	Barometer Pressure, In. of Mercury	Temperature, Degrees Fahrenheit	Density of Air, Lb. per Cu. Ft.	Relative Density δ	$\frac{1}{\sqrt{\delta}}$
0	30.0	60	0.0763	1.000	1.000
5000	25.1	45	0.0657	0.861	1.078
10000	20.8	30	0.0561	0.735	1.167
15000	17.1	15	0.0476	0.624	1.266
20000	13.7	0	0.0394	0.516	1.392
25000	10.7	-15	0.0318	0.417	1.549
30000	8.0	-30	0.0248	0.325	1.754

The maximum speed of the plane is rapidly decreased with increase in altitude, because the charge which the conventional internal-combustion engine gets for power generation is directly proportional to the density of the air. Neglecting the effects on the carburetion of air pressure and temperature, it is possible to find approximately how engine power will fall off as the plane rises. The factors entering are the density of the air, the friction losses in the engine and the resistance from the propeller. The propeller torque varies as the product of air density and the square of the speed, in revolutions per minute, or as δn^2. The engine charge per cycle (and hence torque) corresponding to "indicated" horsepower, is proportional to δ. If the engine had a mechanical efficiency of 100 per cent, δ would cancel from the equation of engine torque to propeller torque, and the engine speed would not vary with altitude. The propeller (and engine) power vary

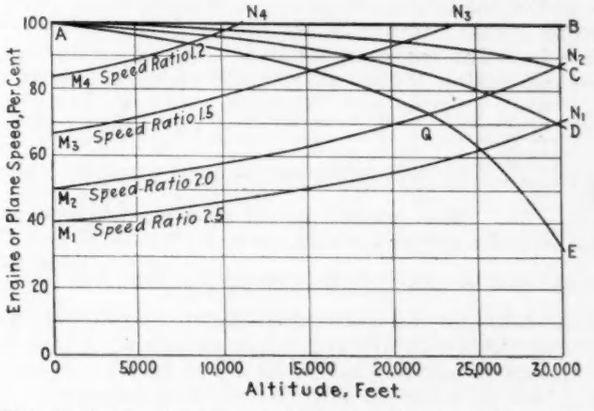


Fig. 1—Engine, Plane and Propeller Speeds at Different Altitudes

Curves *AB, AC, AD, AE*, maximum speeds of horizontal flight for internal combustion engines of mechanical efficiencies (near ground) of 100, 90, 80, 70 per cent respectively.

Curves *MN*, minimum speeds of horizontal flight, from various origins M_1, M_2, M_3 M_4.

Note—This article, which is No. 1 of the publications of the Department of Experimental Engineering, Sibley College, was written in November, 1917, and submitted to the National Advisory Committee for Aeronautics. Professor Durand gave permission to publish the article. Slight changes from the original form have been made to bring the article up to date, while retaining its essential information.

*Assistant Professor of Experimental Engineering, Cornell University

as δn^3. For the engine of 100 per cent mechanical efficiency the maximum power would therefore fall off with altitude in the same proportion as δ does.

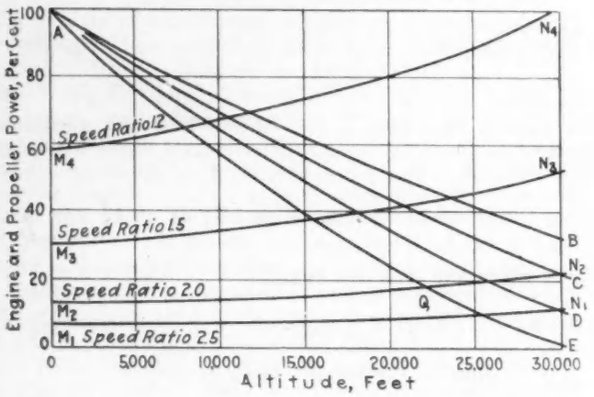


FIG. 2—ENGINE AND PROPELLER POWER AT DIFFERENT ALTITUDES

Curves *AB, AC, AD, AE*, maximum power available at various altitudes from conventional internal combustion engines of mechanical efficiencies near ground level respectively 100, 90, 80, and 70 per cent.

Curves *MN*, power required for minimum sustained horizontal flight; each *MN* curve starts from a different origin, corresponding to speed ratio.

Since the mechanical efficiency of the engine is not 100 per cent, one must make some assumption regarding the friction losses. The easiest assumption is that friction torque is constant. This is really the statement, well known as nearly true for steam engines, that friction horsepower is independent of load. The steam engines are constant-speed machines; when speed change occurs the statement takes the form as above that friction torque is constant. Representing the friction torque of the airplane engine by k, a constant, the effective or "brake" torque of the engine is proportional to $(\delta - k)$. The engine speed is determined by the equation of engine torque to propeller torque, comparing $(\delta - k)$ to δn^2. Then n^2 varies as $\frac{(\delta - k)}{\delta}$, or n varies as $\sqrt{\frac{(\delta - k)}{\delta}}$. Power, computed from the propeller, varies as on δn^3. The calculations of maximum power and engine speed versus altitude, given in Tables II and III should now be clear. It may be pointed out that $\frac{(\delta - k)}{\delta}$ in the tables is the mechanical efficiency of the engine, and decreases with altitude. This change is well known to makers of agricultural tractors, but does not seem to have been noted as such by the airplane engineers.

TABLE II—RELATIVE POWER AVAILABLE AT DIFFERENT ALTITUDES

Altitude, Ft.	Mechanical Efficiency at Ground Level, 70 per Cent					
	Indicated Torque, δ Relative	Brake Torque $(\delta - 0.300)$	Mechanical Efficiency $\frac{(\delta - 0.300)}{\delta}$	$\sqrt{\frac{\delta - 0.300}{\delta}}$	Relative r.p.m. n	Power Relative
0	1.000	0.700	0.700	0.837	1.000	1.000
5000	0.861	0.561	0.652	0.807	0.962	0.767
10000	0.735	0.435	0.592	0.769	0.919	0.571
15000	0.624	0.324	0.519	0.720	0.860	0.397
20000	0.516	0.216	0.418	0.646	0.772	0.238
25000	0.417	0.117	0.281	0.530	0.633	0.106
30000	0.325	0.025	0.077	0.278	0.332	0.012

If a plane is flying horizontally at maximum power and at a constant angle of incidence, the power used is proportional to the product of air density and the cube of the speed, or $P = \delta V^3$. Hence $V = \sqrt[3]{\frac{P}{\delta}}$; and since $P = \delta n^3$, $V = \sqrt[3]{\frac{\delta n^3}{\delta}} = n$. (Proportionality constants disappear through taking values of P, V, n, δ, etc., each as unity at ground level). With this knowledge as to maximum speeds, with Table III giving powers available, and the knowledge that speed and power for minimum sustained horizontal flight vary $\frac{1}{\sqrt{\delta}}$ curves may be plotted as in Figs. 1 and 2, which will show how the "ceiling" of a plane is determined.

Fig. 1 is a plot of speeds vs. altitude. The speeds may be taken indifferently as those of engine, propeller, or plane. The speed is taken as unity for the maximum speed at low levels, and all other speeds are in percentages of this maximum. Curves *AB, AC, AD, AE*, are curves of maximum speeds vs. altitude, for mechanical efficiencies of engine at sea level of 100, 90, 80, and 70 per cent, respectively. Curves M_1N_1, M_2N_2, etc., are curves of minimum speeds vs. altitude, for sustained horizontal flight. Curves M_1N_1, M_2N_2, etc., differ among themselves by starting from different performances at ground level, as measured by the value of the speed ratio of maximum to minimum speed. M_1N_1 is for a plane having a speed ratio at ground level

TABLE III—RELATIVE POWER AND SPEED AT VARIOUS ALTITUDES FOR ENGINES OF DIFFERENT MECHANICAL EFFICIENCIES

Altitude, Ft.	Mech. Eff. 100		Mech. Eff. 90		Mech. Eff. 80		Mech. Eff. 70	
	Speed	Power	Speed	Power	Speed	Power	Speed	Power
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5000	1.000	0.861	0.990	0.835	0.980	0.810	0.962	0.767
10000	1.000	0.735	0.979	0.690	0.955	0.640	0.919	0.571
15000	1.000	0.624	0.965	0.561	0.922	0.489	0.860	0.397
20000	1.000	0.516	0.945	0.435	0.876	0.347	0.772	0.238
25000	1.000	0.417	0.918	0.323	0.807	0.219	0.633	0.106
30000	1.000	0.325	0.876	0.219	0.702	0.114	0.332	0.012

of 2.5, maximum to minimum; M_2N_2, M_3N_3, M_4N_4, for speed ratios of 2.0, 1.5, and 1.2. The best planes have speed ratios approaching 2.5. A plane with a speed ratio of 1.0 could not rise at all, because it would have for climbing no surplus of power over that required for mere maintenance of level. The intersections of the curves of maximum speeds, *AB, AC, AD, AE*, with the curves *MN* of minimum speeds, determine the ceiling of the plane represented. Thus, for a plane of speed ratio 2.0 at sea level, with an engine of 70 per cent mechanical efficiency, the ceiling is found from the intersection of *AE* with M_2N_2, at *Q*, to be 22,000 feet.

Fig. 2 plots power values against altitudes, as Fig. 1 does speeds. The lettering of the two figures is identical at corresponding points. The curve *AB* in Fig. 2 shows the power loss of a mechanically perfect conventional (Otto cycle) internal-combustion engine (100 per cent mechanical efficiency) vs. altitude, due simply to decrease in density of the air. *AB* of Fig. 2 is also the curve of relative density vs. altitude. *AC, AD, AE* are the power curves of engines of 90, 80, and 70 per cent mechanical efficiency at ground level.

By noting intersections of curves *AB*, *AC*, etc., with *MN* curves, of Figs. 1 and 2, it is easy to find the ceiling values of machines with varying degrees of excellence of plane and engine. These ceiling values are plotted in Fig. 3 against the ratio of maximum to minimum speeds in low level flying. Curve *AB*, Fig. 3, is for planes driven by internal-combustion engines of 100 per cent mechanical efficiency; *AC*, *AD*, *AE* are similar curves for engines of mechanical efficiencies at ground level of 90, 80 and 70 per cent. Curve *AO*, Fig. 3, is of a different family, showing what might be done with planes if the engines maintained their maximum power constant regardless of altitude. It is derived from Fig. 2 by the intersections of the *MN* curves with the line of constant power, *AO*.

The preceding calculations and the resultant curves of Figs. 1, 2 and 3, have been made possible by a number of simplifying assumptions. The power required to drive a plane at a certain speed depends not only on the speed, but also on the angle of attack, and the angle of attack will not be the same for flight at the maximum and the minimum speeds. The engine friction is not entirely independent of load or speed. Carburetion does change with pressure and temperature. Indicated power is not directly proportional to air density, for thermal efficiency changes with compression. Hence the curves of Figs. 1, 2 and 3 are not exact; one cannot expect to pick from Fig. 3, for example, the precise value of the ceiling for a given plane. It is fair to claim, however, that the values shown are of the right order of magnitude, that the methods used are sound though not precise, and that the relative values shown are correct.

It is practically certain, for example, that for a plane of speed ratio at ground somewhere around 2.0 to 2.5, every added 10 per cent of mechanical efficiency of the engine (tested at ground level) means a gain of not far from 4000 ft. in ceiling. There can be no question that such an advantage is worth going after. An advantage of a thousand feet in ceiling is practically decisive in airplane fighting, because it represents also maneuvering power. The point *Q*, Fig. 1, shows that a plane with ground performance of maximum speed 100 m.p.h., minimum speed 50 m.p.h., engine mechanical efficiency 70 per cent, has a ceiling of 22,000 ft., at 73 m.p.h. speed. It cannot go faster than 73 m.p.h. for lack of power; it cannot climb higher; and if it goes slower it loses altitude. A competing plane, alike in weight and ground performance, save that engine mechanical efficiency is 80 per cent instead of 70, will have at 22,000 ft. a possible maximum speed of 85 m.p.h., and hence can at will maneuver around the first plane at constant altitude by use of the higher maximum speed, or go above the first plane by some 3000 or 4000 ft., and then come down at high speed to attack. Only at the ground level will the two planes be equal in performance; the greater the altitude the greater will be the advantage of the machine with the more efficient engine in horizontal speed or climbing speed or maneuvering ability.

To get high mechanical efficiency we turn first to the pistons of the engine, for piston friction is likely to be the largest friction in the engine. We make the piston clearance as large as we dare without inviting leakage, and use special piston rings to stop leakage while not pressing too hard against the cylinder. We make special provision for cooling by ribbing the piston inside, and perhaps thickening the piston head, thereby helping to oil the piston, and stop the gumming of the rings with spoilt oil. With large clearance we need to provide for returning excess oil to the inside of the piston, rather than have it get above the piston into the combustion space. We may consider offsetting the cylinders to reduce the side pressure of the piston on the cylinder walls during the power stroke; a moderate offset will probably pay in decreased friction.

For the crankshaft we may consider the use of roller bearings. Before we go to that extreme, however, we will see what can be done with plain bearings. Properly lubricated plain bearings can be nearly as good as ball or roller bearings. The pistons must be oiled anyway, so that plenty of oil is available for the crankshaft main bearings and crankpins. The first principle of proper lubrication of a plain bearing is that the oil should be supplied on the unloaded, not the loaded, side of the bearing. Oil should enter the top half or the sides of the

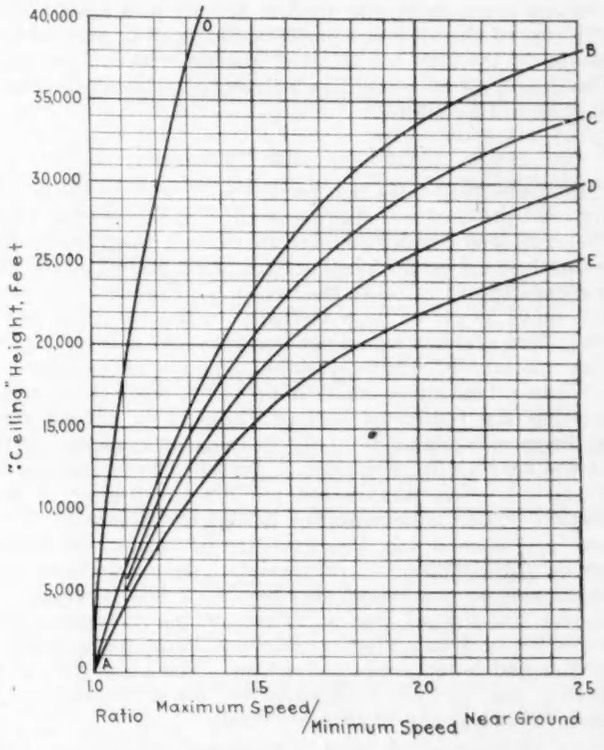


FIG. 3—CEILING HEIGHT FOR CONVENTIONAL AND THEORETICAL CONSTANT-POWER ENGINES

AO is curve for power constant, independent of altitude. *AB*, *AC*, *AD*, *AE* are for power from internal combustion engines of conventional design, with mechanical efficiencies near ground level of 100, 90, 80, and 70 per cent respectively.

Best present practice with gasoline engines is in neighborhood of speed ratio 2.0, mechanical efficiency 80, ceiling 25,000 ft.

main bearings and the bottom half or the sides of the crankpin bearings. Exact determination of the proper place for oil supply follows upon a careful analysis of the combined explosion and inertia forces through the entire cycle of operation of each particular engine. The pressures in the oil film on the loaded side of a bearing are high—very high. The nominal pressure on crankpin bearings at explosion may be 1500 lb. per sq. in. The real pressures in the oil film at explosion vary from zero at the ends of the bearing and at the split of the bearing, at 90 deg. to the direction of loading, to about 15,000 lb. per sq. in. in the center of the loaded area, over the high spots of the bearing metal. What can the 15 or 50 lb. per sq. in. of "pressure feed" oiling do against pressures such as 1500 or 15,000? If we try to feed oil to the center of

the loaded half of a bearing we furnish a channel for the oil to go out by. If the loading were steady the lubrication would fail absolutely; but in the internal-combustion engine the loading on a crankpin or main bearing is unsteady, or partly reversing, so that almost any oil-feeding system will work after a fashion.

There should be no oil grooving in the middle of the most loaded half of a bearing; such grooves are merely channels of escape for the oil from the region of highest pressure in the oil film. For the internal-combustion engine the proper place for the oil distributing channels is in the plane at right angles to the line of the load forces, which commonly is also the plane on which the bearing is split. A chamfering of the edges of the halves of the bearing makes a good and sufficient groove.

The principles of oil supply to plain bearings are few and simple. Oil should enter at the point where the average pressure in the oil film has its minimum value. The rest of the bearing should be designed to prevent the escape of the oil—not to let it get out without working. The supply of oil should be more than adequate—a surplus should be offered.

Oil Film Under Pressure

Pressure feed does not force the formation of an oil film; the pressures used are absurdly inadequate for that. Pressure feed can only ensure that oil channels will clear themselves of small obstructions, and so maintain an adequate supply of oil to the bearings. Pressure feed will also move an oil of high viscosity to the bearings when other feed systems would not move it; and will make possible special oil feeds to all dubious points of a system.

When a bearing is made improperly, with oil grooves crossing the region of highest pressure in the oil film on the most loaded side of the bearing, it is necessary to set the bearing up very close to prevent the entire escape of the oil. The thinner the oil film the higher is the friction. Such a bearing has a high coefficient of friction, and a relatively low pressure of seizure at which the oil film breaks. A competing bearing without the oil grooves on the loaded side has much less tendency to squeeze out the oil, has a higher seizing pressure, and can be set up with a greater clearance, hence has a thicker oil film and lower running friction. The properly made bearing has greater load capacity, lower friction and longer life than one improperly made.

The reiteration of what constitutes the proper and improper place and manner of the oil supply to plain bearings may seem tedious and unnecessary. It is not unnecessary. Airplane engines require dis-assembly and overhaul for bearing troubles commonly after about one-tenth the hours of service which good automobile engines give. The reason for this is in part of course the fact that the airplane engine runs always at or near full throttle, and the automobile engine does not. But another large reason is that many airplane engines have not good design for lubrication.

Curtiss engines have had their bearing design changed rather recently. Whether the Curtiss engineers happened to look inside a Ford automobile engine, or got a hint from their British customers, we do not know. Curtiss bearings are right now, and a few years ago they were not. Bearings fed with oil from the bottom of the main bearings, with X grooves in the loaded side of the bearing, set up tight to keep the oil from squeezing out entirely, are bad. The point will immediately be made that the Mercedes engine, which is generally admitted to be a good engine, has the design of oiling system which is here condemned. The answer is that the lubrication of the Mercedes is in spite of, not because of, the design, and could be greatly improved by proper design.

A question arises as to the Liberty airplane engine, upon the excellence of which many lives and great interests are soon to depend. It has now been announced that the lubricating system of this engine was not at first satisfactory, and that it was redesigned and improved. Reliability, durability and performance at high altitudes depend upon having the lubricating system correctly designed. It is just as easy and just as cheap to build it right as to build it wrong. Good workmanship can and often does compensate for bad design; good workmanship with good design will be still better. We want our aviators to have the extra 4000 feet of ceiling that goes with 10 per cent higher mechanical efficiency in the engine.

The further study of the calculations and data plotted in Figs. 1, 2 and 3 suggests for aviation some possibilities far more radical than a mere attempt at the highest possible mechanical efficiency in a conventional internal-combustion engine. It suggests that we seriously modify the internal-combustion engine or drop it entirely in favor of steam.

A modification greatly needed for the internal-combustion engine is some provision for "supercharging." If some device can be made which will enable us to increase the volume of air drawn in on the suction stroke, to compensate for the decreasing density of the air as altitude increases, we may then be able to stop the power losses at altitudes indicated in Fig. 2, curves *AB, AC, AD, AE*. We will not want to do supercharging at low altitudes, because that would raise our compression pressures and run into preignition troubles besides, perhaps, spoiling our factors of safety in construction of engine parts. What we want most is a supercharging which increases in volume capacity as altitude increases, just enough to keep our compression and explosion pressures independent of altitude.

Constant Air Pressure

If, by the use of a variable supercharging, we could keep our charge weight and hence engine power constant, independent of altitude, that one change would multiply the possible ceiling heights by about three. The power curve of the engine would be *AO*, Fig. 2. The curve M_1N_1 of power at minimum speeds for a plane having a speed ratio, maximum to minimum, at ground level of 1.2, cuts the power curve *AD* at less than 10,000 ft. of ceiling value. The same curve M_1N_1 cuts the constant power curve *AO* at about 30,000 ft. ceiling. A plane with a speed ratio of only 1.2 is a pretty poor one; but if it had a supercharging engine, capable of constant power regardless of altitude, it would at high altitudes be so enormously superior to any competing plane with an ordinary engine that it would wholly outclass it. The same conclusion may be reached from comparing the curve *AO*, Fig. 3, with the curves *AB, AC, AD, AE*. Remember that any advantage in ceiling means a great advantage in speed and maneuvering power at high levels.

If we cannot contrive the supercharging or some equivalent device for the internal-combustion engine, to keep it from power loss as altitude increases, then we might better discard this engine entirely for high altitude work and develop a steam powerplant for airplanes. We know that we can make the steam plant maintain its power

practically regardless of altitude. This ability of the steam plant is so important for high-altitude work that we might tolerate even more than double the weight per horsepower at ground level, and still have the steam plant better than any conventional internal-combustion engine. For low-level flying, meaning thereby less than 10,000 ft., there is little doubt that the internal-combustion engine will long remain the better power source. If our ambition or military need is for flying at 20,000 or 30,000 or 40,000 ft., then steam must be considered. There ought not to be much difference in weight between a steam powerplant and an internal-combustion engine fitted with an adequate supercharging device; and as to ease of control, durability, reliability and freedom from trouble, the former would almost surely be the better.

I have attempted to show, through the use of certain simplifying assumptions, the general nature and approximate numerical value of the effects of altitude on the performance of airplanes and airplane engines. From this investigation certain conclusions stand out with unexpected clearness. The value of a plane, for military purposes at least, depends not only on performance near the ground level, but on great climbing and maneuvering ability, and on the retention of these at high altitudes. The maneuvering value of the machine at high altitudes depends on the ceiling of the machine. After a certain ground-level performance is obtained, the most important factor in keeping that performance good at high altitudes, if the engine is of the conventional internal-combustion type, is high mechanical efficiency in the engine. Hence the correct design and construction of the lubricating system of the engine is of the highest importance.

The ordinary Otto cycle type of combustion engine is inherently unsuited to high-altitude work, because of its loss of power as the density of the air decreases. The internal-combustion engine can be made fit for high-altitude work by a supercharging scheme, if such a scheme can be made to compensate for change of density of the air. A doubling of the engine weight by the supercharging device might even be tolerable, so great is the advantage gained by maintenance of power to high altitudes. If the internal-combustion engine cannot be modified by a successful supercharging device, it should be discarded and a steam-plant substituted, because the steam-plant has the inherent ability to maintain its power regardless of altitude. This conclusion is irresistible, for the airplane which does not lose power with altitude can go about three times as high as one with a conventional internal-combustion engine, though the performance of the two at the ground level is identical. It seems probable that in the future internal-combustion engines of the present conventional design will furnish power only for airplanes intended for flight below 10,000 ft. altitude, the power loss of the engine within that range being tolerable; and for greater altitudes steam power-plants will be used.

NOMINEES FOR SOCIETY OFFICERS

THE 1918 Annual Nominating Committee provided for by Section 46 of the Constitution has completed its work. In accordance with the By-laws, the Committee organized at the meeting of the Society held last June in Dayton. The Committee has submitted the names of consenting nominees for the elective offices next falling vacant under the Constitution, as follows:

For President (to serve one year), Charles M. Manly.

For First Vice-president (to serve for one year), B. B. Bachman.

For Second Vice-president, representing Motor-Car Engineering (to serve for one year), E. H. Belden.

For Second Vice-president, representing Aviation Engineering (to serve for one year), Elmer A. Sperry.

For Second Vice-president, representing Tractor Engineering (to serve for one year), T. B. Funk.

For Second Vice-president, representing Marine Engineering (to serve for one year), John J. Amory.

For Second Vice-president, representing Stationary Internal Combustion Engineering (to serve for one year), L. S. Keilholtz.

For Members of the Council (to serve for two years), David Fergusson, E. A. DeWaters, and E. A. Johnston.

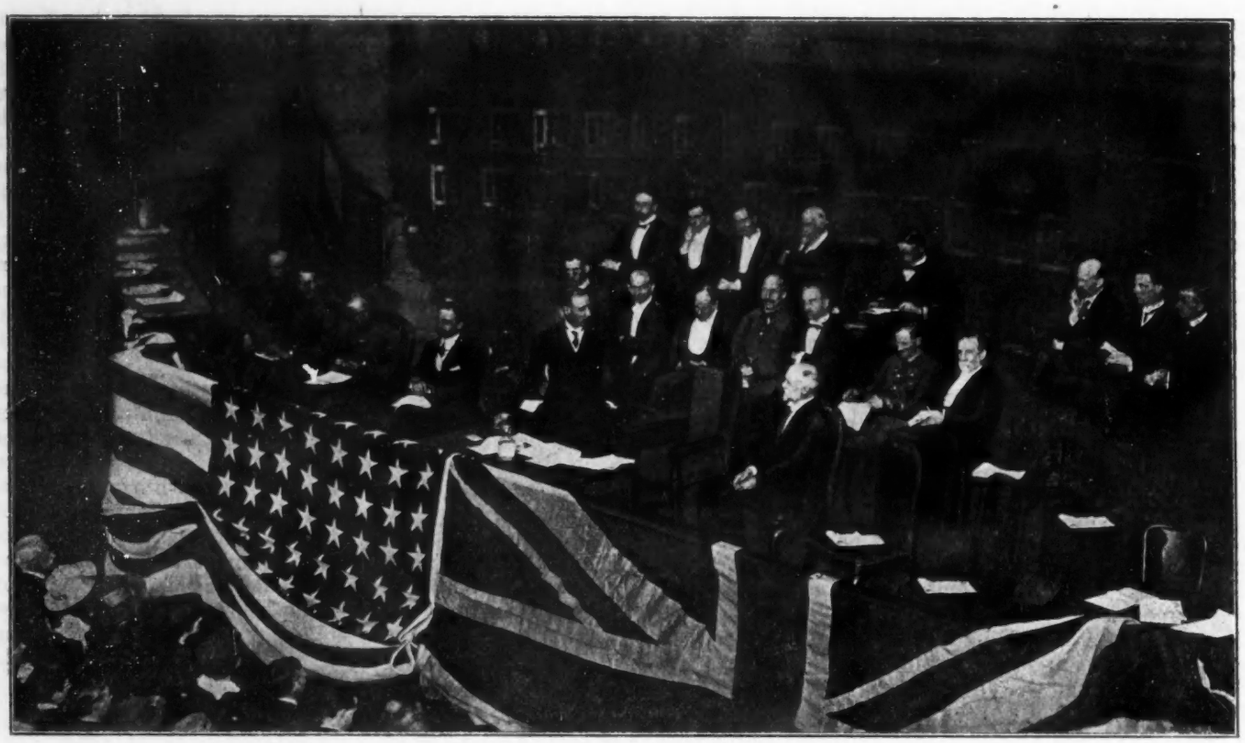
For Members of the Council (to serve for one year) Charles S. Crawford and J. V. Whitbeck.

For Treasurer (to serve for one year), Charles E. Whittelsey.

The Nominating Committee was constituted of three Members at large, elected at the Business Section of the Semi-Annual Meeting, and eight Members elected by the eight Sections of the Society, as follows:

F. E. Place, Mid-West Section, chairman of the committee; H. R. Corse, Buffalo Section; R. E. Clingan, Cleveland Section; R. E. Wells, Detroit Section, secretary of the committee; W. S. Reed, Indiana Section; C. F. Scott, Metropolitan Section; H. C. Buffington, Minneapolis Section; W. H. Palmer, Jr., Pennsylvania Section. The three Members elected at the last Business Session of the Society were W. A. Frederick, W. P. Kennedy and R. H. West.

Ballots bearing the names of the candidates for office proposed for election will be mailed to each voting member prior to the next Annual Meeting. At the first session of the 1919 Annual Meeting tellers will canvass the ballots and certify the results.



LONDON MEETING OF ROYAL AERONAUTICAL SOCIETY AT WHICH DOCTOR DURAND SPOKE ON JUNE 25TH

Read Left to Right: Back Row—Mr. Holt Thomas, Mr. A. E. Berriman, Mr. Griffith Brewer, Mr. Robinson, Secretary Air Ministry; Mr. Holt Smith, Dr. T. E. Stanton, Mr. Bramwell, Mr. Banstor, F. R. S., Technical Dept. Air Ministry

Second Row—Brig. Gen. Alexander, Mr. Hanley Page, Mr. Horace Darwin, Chairman Air Inventors Committee; Col. M. O'Gorman, Mr. White Smith, Chairman Society of British Aircraft Constructors; Gen. Ellington, Dr. Walmsley, Northampton Polytechnic

First Row—Lt. W. Barnard Faraday, Secretary Royal Aeronautic Society; Lt. A. P. Thurston, Brig. Gen. Lord Montagu of Beaulieu; Major Baird, M. P., Under Secretary of State, Air Ministry; Gen. R. M. Ruck, Chairman Royal Aeronautical Society; Sir W. Weir, Secretary of State, Air Ministry; Dr. W. F. Durand, Chairman National Advisory Committee for Aeronautics of United States

II—Outstanding Aeronautic Problems

By DR. W. F. DURAND*

THE function of the propeller is, of course, to take the torque of the engine and to transform it into a propulsive thrust; or otherwise, to take the power given by the engine to the crankshaft and transform it into driving or propulsive power for the airplane. The problem is further complicated by the fact that, expressed in terms of a power relation, it is not simply the question of an engine handing so much power over to the propeller for the latter to transform into propulsive power. Instead, the power which the engine itself can develop is dependent on the propeller and likewise on the airplane to which they are both attached. We have here, in consequence, a series of complicated implicit relations, and from which the propulsive characteristics of the plane-propeller-engine combination take their origin. In fact, it must never for a moment be forgotten that the moving airplane is, in effect, an airplane-engine-propeller combination, and that no one of the three can be determined independently of the other two.

INFLUENCE OF THE PROPELLER

Without entering into any detailed discussion of this problem, it will be clear that the propeller will exercise a controlling influence on the power which the engine can develop. Thus it is evident that an aeronautical engine, in order to develop power, must be permitted to move its pistons and revolve its crankshaft, in other words, to make revolutions; and, other things equal, the power developed will vary directly with the revolutions which can be realized. Again, it is easy to see that the size and amount of surface of the propeller blades will present a controlling feature regarding the revolutions which can be realized. Thus, the propeller may be enormously oversize, too large in diameter and presenting a large and unwieldy surface to the air. Suppose this to be the case with a plane of size suited to the propeller, but not to the engine—that is, the engine is far too small for either propeller or plane. In such case the engine simply will not be able to make its normal number of revolutions. It will be held down by the excessive resistance to rotation presented under such circumstances, and may thus develop far less than the normal power which it is capable of under proper conditions. Many other combinations may occur which we cannot stop to discuss or even to mention. Broadly speaking, the plane, the engine and the propeller, as the propelling agent, form a most closely

*Chairman National Advisory Committee for Aeronautics. See September JOURNAL for Part I

knit combination, and each interacts in a more or less controlling manner on the operation of the other two.

In order even to make a start with the problem of the propeller, it is therefore necessary to assume conditions regarding both the plane and the engine. If these conditions as assumed are then realized in practice, and if the design has been well carried out, the anticipated results may be reached. If, on the other hand, the assumed conditions are not realized as regards the plane and the engine, then no matter how well the design of the propeller may have been carried out, the anticipated results will not be realized. No matter how good the propeller may be by itself, no matter how carefully designed and constructed, no matter how faithfully it may be able to realize the conditions for which it is designed, if these are not the conditions under which it is actually placed for service, the results, economic and otherwise, will be unsatisfactory; not necessarily by reason of any fault in the propeller as such, but due simply to its lack of adaptation to the conditions of operation. An effective propeller is therefore not only one which is properly designed and constructed in itself, but also one which is permitted to operate under the conditions intended and contemplated in the design.

The general problem of the propeller is by no means, however, to be classed distinctively as outstanding. Instead, an enormous amount of work has been done on it, both theoretically and experimentally, and in its main features it has been brought fairly within the limits of a solved problem. There have been three modes of approach, briefly as follows:—

1 The analysis, geometrically, of the blade of a propeller into a series of elements occupying each a narrow strip running across the blade from leading to following edge, and making up, by their summation, the blade as a whole. Each of these elements or strips is then considered as, in effect, a little elementary aerofoil, and for which the usual aerodynamic characteristics are readily determined, either by direct experiment on a model or by selection or interpolation from and among the large amount of available data regarding such aerofoils which have already been submitted to experimental investigation. With such data in hand relating to the series of elements going to make up the blade, it is a matter of simple computation to combine them in such manner as to represent the action of the blade as a whole, under the conditions assumed, and thus in general terms the problem is solved.

2 A law of similitude is assumed and a small model propeller is tested out experimentally and under conditions which permit, under the law of similitude assumed, the translation of the *observed* results for the model into the *probable* results for the full-sized propeller.

3 Full sized propellers are tested out as nearly as may be under flying conditions, and are made the ultimate basis of design.

The limitations of Method No. 1 arise from the following:

a The coefficients derived for aerofoils correspond to straight-line motion between the air and the foil, whereas in the propeller the relative motion is in a helical or spiral path.

b The actual velocities for which such coefficients are derived are usually speeds not exceeding 60 or 70 m.p.h., whereas the actual speeds of the tip elements of propeller blades may move at speeds of 500 m.p.h. and upward. The extent to which the usual square of the speed law may be extended to such values is not as yet fully known.

c The coefficients used are derived for the various aerofoil sections or elements individually, whereas in the actual propeller they all act conjointly or collectively in making up the propeller blade.

Application of Method No. 1 cannot therefore be made except in so far as it is justified by actual and final experience on full sized forms under flying conditions.

Method No. 2 (that with reduced size models) has the limitation that the law of similitude employed is of necessity not exact but approximate, and the degree of reliance which can be placed on results thus found can again only be determined by ultimate reference to full-sized forms under flying conditions.

Method No. 3 (that with full-sized forms under actual flying conditions) has the limitation of very high cost, both in equipment and time, and as a result of which only a relatively small number of forms can actually be subjected to adequate test in this manner.

Again, Method No. 1 (that of computation based on coefficients determined by laboratory experiment) has the advantage of requiring only a pencil and pad of paper with a table of pre-determined coefficients. No. 2 (that with the small models) has the advantage over No. 3 of relatively small cost, of permitting the tests to be carried out in a wind tunnel with all conditions under control, and finally to permit of carrying quickly through the test program a very large number of types and forms. It should perhaps be stated here that as between Methods No. 1 and No. 2, the latter is accepted as much the more reliable of the two. In fact, it is not too much to say that when used with judgment it furnishes a very satisfactory and well-nigh universally accepted method for dealing in a laboratory way with most problems of propeller design and operation.

These phases which thus stand out represent in effect the lack of an adequate correlation between the three methods of approach as above described.

It is obvious that if we could develop an adequate and reliable correlation between the results of the computation according to Method No. 1, and the final test under flying conditions according to No. 3—if, in other words, we could adequately determine the error of No. 1 and hence the correction to be applied in any given case, then a pencil and pad of paper would go a long way toward furnishing the material for the solution of the problem of propeller design, once we are permitted, of course, to assume a definite set of operative conditions.

Or, again, if we could know more accurately and more widely the character and amount of error to be anticipated in the use of the small models according to Method No. 2, we should be in a position to use the experimental model method with better assurance of definite and reliable results for the full-sized propeller later to be constructed.

It seems likely that this final correlation of computation with ultimate result may best be made in two stages. The first should comprise a careful study of the relation between the results derived by the computations of Method No. 1 and the model tests of Method No. 2. Such a correlation would then permit us to pass readily from the results by computation to the probable results by model.

The second correlation should then comprise a series of comparative tests to determine with sufficient generality of application the character and amount of correction to be applied to the results of model test, in order to

satisfactorily reproduce the results to be expected from full-sized forms.

This would by no means require the testing of a full-sized form corresponding to each model. If so, there would, of course, be no use in making model tests. The whole program might as well be carried out directly by tests on full-sized forms. It appears reasonable to expect, however, that a well-selected and not too numerous series of tests, properly distributed among the various characteristics of form and of operation, would serve adequately to give the correlation desired.

With such correlations established we should then have two methods, Nos. 1 and 2, available for the design of propellers. No. 1 available with no more than a pencil and pad of paper (once the standard section coefficients are determined), and No. 2, by model, ready to supply a vast amount of detailed information regarding operation under varying conditions, and which may be realized rapidly and effectively once the model is made.

If we have spent so much time over these matters relating to the propeller, it is because of its importance as an element in aerial navigation, and in order that we may the better note just what part of the general problem is still outstanding.

This, as we have seen, lies primarily in the matter of the correlation between the three methods outlined. There is, indeed, need for continuing experimental research, especially on systematically selected forms, both model and full size; and such continuing experimental work combined with carefully directed studies of correlation will go far toward giving us an assured and adequate basis for the practical solution of the propeller problem as applied to aerial navigation.

Reaction between Propeller and Plane

Perhaps the widest and most important outstanding problem in connection with airplane propulsion has relation to the reaction between the plane and the propeller—the influence of the structures adjacent to the propeller on its performance, economic and otherwise, and the influence of the propeller on the plane, both as regards its lift and its net resistance to propulsion. This is a field which is largely outstanding. It must be attacked chiefly by the experimental method—by model, with results checked up by comparison with full scale trials so far as practicable.

Multiple Propellers on One Shaft

Of a closely related nature is the problem of the interaction of two or more propellers on one shaft. This is a problem which is becoming of importance in connection with the increase in power of airplane powerplants and with the fitting of more than one propeller on the same shaft.

This likewise is a problem which must be approached experimentally—again through model research checked up by comparison with full scale tests. A beginning has been made on this most important and interesting problem, and we may expect in a not distant future to find it brought within limits of control similar to those surrounding the problem of the individual propeller.

In addition to these problems which relate to airplane propulsion in its general aspects, and more especially when for the sake of simplicity we assume that the airplane remains under a uniform regimen as regards external conditions, there arises a problem of very great present importance, that of some form of adjustment in the technical characteristics of the plane as a whole, permitting it to be made responsive to variations in the regimen of operation, as, for example, change in the density of the air due to change in altitude, or change of regimen required for climbing flight as compared with horizontal flight.

In connection with the prime mover, mention was made of the very important problem of maintaining power at altitude in spite of the decrease in the density of the air. In reality this problem is very intimately bound up with another of scarcely less importance, that of devising means for effectively using such power for propulsive purposes. Without attempting any technical discussion of the question, it will be apparent that the whole problem of the operation of the propeller as a means for absorbing the power of the prime mover and converting it into the propulsion of the plane will depend on the density of the medium in which and on which it operates. Again, in climbing flight a part of the weight of the airplane is carried by the pull or thrust of the propeller. In horizontal flight it is all borne by the planes (assuming the propeller shaft then horizontal). Hence, the pull or thrust of a propeller, and, indeed, its whole regimen of operation, may vary widely, according as the plane is climbing or flying horizontally. It thus seems reasonable to conclude that for the best results there should be provided some mode of adjustment or compensation, so that the propeller, as it finds itself operating in a medium of continuously decreasing density, or as it finds itself called upon for varying amounts of thrust or pull, with varying angles of climbing flight, may be correspondingly adjusted in order to give continuously the best results.

The problem is further complicated by the fact that the airplane itself needs a correlative adjustment. As we have already seen, the one factor in aerial flight which remains sensibly constant under all conditions and at all altitudes of flight is the weight of the plane and its equipment. The vertical supporting force gained from the reaction of the air must therefore be maintained constantly equal to this weight at least for the conditions of horizontal flight, while for climbing flight the weight will be divided and borne partly by the supporting planes and partly by the propeller. The problem of the economic use of power at varying altitudes and under varying angles of climbing flight involves, therefore, the following chief elements:

The weight of the plane.
The surface of the wings and their aerodynamic characteristics.
The angle of attack of the wings.
The speed.
The power developed by the engine.
The revolutions of the propeller.
The area and form of the blades of the propeller.
The pitch of the propeller.

These various factors react and interact in a most complex manner, and any attempt to discuss the problem in detail would carry us too far afield on the present occasion. We may note, however, that the angle of attack is the one feature about the plane which may readily be varied, while there is no feature of the propulsive agent, the ordinary propeller, which admits of equally simple correlative variation. What is needed with regard to the propeller is, indeed, some means of realizing an adjustment correlative to the change in the angle of attack for the plane. To this end a change of pitch is most suitable, some means of varying, at the will of the pilot, the pitch

of the propeller in order that, with the fixed diameter and area of surface, and with the work available per revolution of the engine as affected by the density of the air, the pitch may be so adjusted as to secure the number of revolutions best adapted to the economic use of the power given out by the prime mover. This will then ensure the thrust needed to overcome the resistance of the plane at the angle of attack and speed which, taken conjointly, will give the lifting force needed to support the weight of the plane, either in whole or in part, according as the plane is flying horizontally or climbing.

Propeller with Adjustable Pitch

All of this somewhat complicated statement means simply that what is wanted is a propeller with blades adjustable for pitch. Such a propeller may be realized by so pivoting the blades that they may be turned about a radial axis, thus changing their angle relative to the axis of the propeller itself. Extreme changes of such a character result in a very wide variation of pitch from root to tip, and in the end will result in a serious loss of efficiency. There are therefore two problems involved:

1 The aerodynamic problem of determining the best form and proportions of a propeller, the blades of which are intended to be pivotable in this manner, so that under the widely changing conditions of flight which may be met with there may be effective operation and a well-sustained efficiency.

2 The mechanical problem of so designing and building a propeller with adjustable blades that it will meet the rigorous requirements imposed upon it by the exacting conditions of airplane navigation.

It is perhaps not too much to say that the first problem is already well in hand. We know reasonably well what forms and proportions to give to such a propeller, and if it were only a matter of design or of the determination of form and proportion the problem could hardly be called outstanding.

As much cannot be said regarding the second problem. The practical construction of a propeller with adjustable blades is not an easy matter. Several modes of construction have been attempted but with only moderate success. The problem is clearly defined, of the highest order of importance, and is outstanding as one of the appliances for which the art of aerial navigation is definitely waiting.

STABILITY AND CONTROL

The three fundamental requisites of an airplane are strength, movement, and stability with control. We have noted some of the problems arising under the requirements of strength and movement or propulsion. We may now turn briefly to a glance at the situation regarding stability and control. Any detailed discussion of these problems would be quite out of the question on the present occasion, and time in any event will only allow us a brief glance at the general situation.

Regarding stability and control it is not too much to say that the general principles underlying these characteristics of an airplane are now reasonably well understood, due largely to the splendid theoretical and experimental investigations initiated by British scientists and to which certain workers in the same field in the United States may have contributed something, and by no means overlooking certain important contributions by French and Italian investigators. These investigations, both analytical and experimental, have placed the study of these subjects on a reasonably sure foundation, and have served to mark out the way to secure any desired degree of stability which may be desired or which may be consistent with other valuable qualities. We are here confronted with one of those situations, so frequently encountered in scientific and technical work, where a choice must be accepted on some middle ground between wide extremes, and where the attempt to secure some desirable quality in high degree may lead to a limitation of desirable qualities in other directions.

So it is with stability and control. If stability is carried to an extreme then mobility and quickness of maneuvering are reduced, and control in the sense of ready response is lacking. For military purposes, especially for machines of the fighting type, where mobility is of the highest importance, this would be a serious shortcoming, and hence such machines cannot be given too much stability in the ordinary sense of the term. On the other hand, for heavy machines of the bombing type, where mobility of evolution is not so vitally important, the margin of stability may be greater. Going to a still further extreme, it is easy to build a safe moderate-speed family-carriage sort of machine which will be stable and secure under almost any conditions likely to develop. Such machines would be scorned by fighting pilots, but when civil aeronautics begins to come into its own after the war and under peace conditions, and there comes a demand for safe machines for civil purposes, including family outings for the week-end from the city to the country or to the sea-coast, then we may anticipate a larger recognition of the qualities making for safety and stability, and we shall find machines provided having such characteristics and in practically any desired degree. Here again, however, there will be degrees of choice because it will be found that with too high a factor of stability what may be termed the riding qualities of the plane will be poor, while with low stability the riding qualities may be much smoother.

The general problem is, therefore, pretty well solved, so far as the groundwork is concerned. This does not mean, however, that there is nothing further for us to learn in this connection. There are many problems of a detailed nature inviting the student of this fascinating field of study, and the solution of which will serve to round out and broaden our general grasp of the problem. In particular, we need further study on the interaction between elements which ensure stability and those which permit mobility and readiness of response to control agencies, to the end that we may control more effectively the combinations which may be desired regarding stability and mobility of evolution.

Again, while the elements of control are well understood, there is room for further study as to the best means of actually developing the control forces required and of applying them to the plane itself. These are partly aerodynamic and partly structural problems, each phase reacting more or less on the other.

One instance of problems of this character will serve to illustrate the type.

We know that an airplane is provided with rudder surfaces of two kinds, one to determine movement in a vertical motion, up or down, and the other to determine horizontal motion, right or left. But these motions, vertical and horizontal, assume that the plane itself is horizontal or sensibly so. However, when a plane is circling on a steep spiral or making a quick turn, it is inclined or "banked," in order to avoid side slipping, until, in extreme cases, the wings are nearly vertical, and frequently

much more nearly vertical than horizontal. In such cases the functions of these control services are reversed. Those which, with normal aspects, serve to produce movement right and left, will now serve to determine motion rather in a vertical direction, and those which formerly served for movement up and down will now serve to determine motion to the right or left. For intermediate angles of bank each set of control surfaces will give control forces in both directions, up or down and right or left.

Now it is by no means sure, having in view this double and interchangeable function between these two sets of surfaces, whether we have as yet realized the ultimate and best arrangement either as regards the surfaces themselves or their control by the pilot.

It seems decidedly probable that we have not, and that, some arrangement yet remains to be devised which will be more effective in the matter of this double and interchanging function of control, and simpler in its relation to the pilot.

Armament and Instruments

There still remain two large and important fields, rich in aeronautic problems. These are armament and instruments. I shall attempt no more than the briefest general reference to these two classes of problems.

Those arising under the head of armament are, of course, strictly military in character and but little of interest could, in any event, be said in a public address. Such problems relate naturally to the number, type, and size of guns to be carried, their mounting and special sights; bombs and devices for carrying, aiming, dropping, etc.; questions of armor and protection of vital parts against gunfire or shrapnel bursts, etc.

Expressed in their most general terms these problems resolve themselves into an attempt all along the line to meet the requirements imposed by the desired military uses of the plane, and to anticipate or improve upon the devices and designs of the enemy in the same fields.

Regarding instruments, little more specific can be said. This field does, however, bristle with problems of the highest interest to the scientist, and may well challenge his best efforts. It is interesting to note the extent to which the modern airplane has become a flying meteorological and physical laboratory. Thus, a recent list of airplane instruments shows some 25 or 30 different instruments and devices, not indeed all to be carried on one plane, but all included in the general aeronautic military program, and each serving some specific and important purpose.

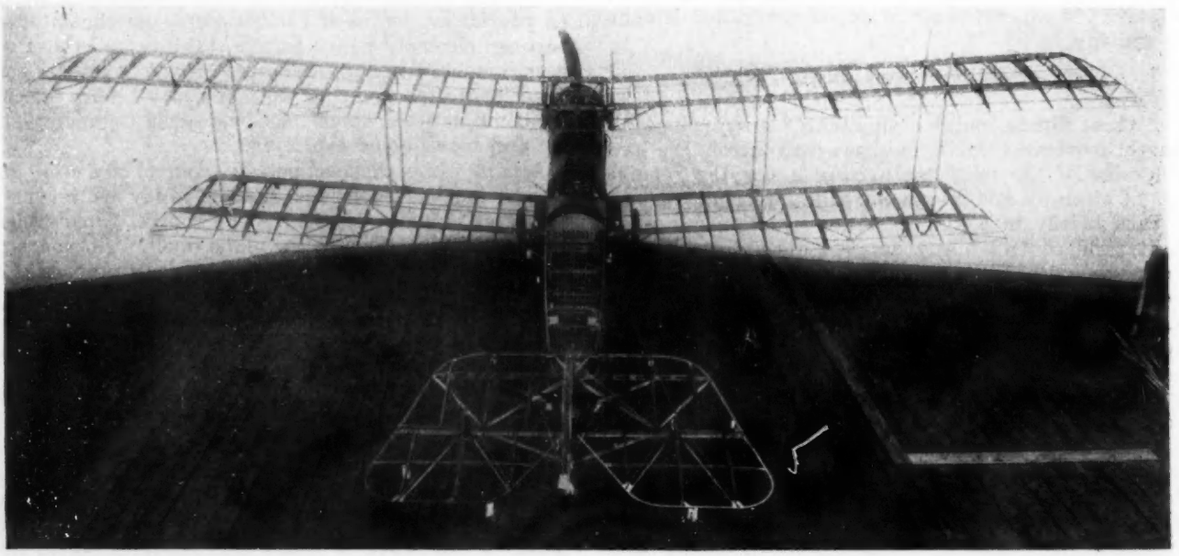
With these instruments, as with armament, the problems reduce themselves to an effort to meet the military or the navigational and operative requirements of the situation, and in these days of war in particular, to anticipate or improve upon the similar devices and designs of the enemy.

Much of the work relating to these problems under armament and instruments is already done and well done. There do remain, however, many problems, especially of detail or of improvement, which must be considered as outstanding; but of these I shall attempt no mention or discussion.

By way of conclusion, reference may, for a moment, be made to a problem of the most vital and far-reaching economic importance, which will be upon us with the arrival of peace conditions. This is the problem of the best economic utilization of the enormous investment which has been made in aeronautical production, expressed in terms of money and human time and energy, and now represented by factories, machinery and equipment, finished product, trained industrial organizations, human skill and productive capacity.

The discussion of such a problem might well occupy our careful attention for the entire hour, but I can no more than mention it here by name. We can, however, scarcely over-exaggerate its importance, and the appointment of important commissions in England and in the United States for the study of the problems arising under this general head is an evidence that their serious import is appreciated, and we may hopefully await suitable measures of adjustment against the day when we may again turn our thoughts to the occupations of peace.

And so with all our problems; we can only look hopefully forward for the future to give to us such measure of answer as our patience and study may merit.



Skeleton View of a Curtiss JN 4 Plane

ANTIFREEZING SOLUTIONS FOR AUTOMOBILE RADIATORS

THE subject of antifreezing solutions for automobile radiators has been brought very forcibly to the attention of users of motor vehicles this winter, and many requests for information regarding their use have been received by the Bureau of Standards, Department of Commerce. An investigation was undertaken by the Bureau to establish the value of these compounds and sufficient data have recently been obtained to justify a preliminary statement.

The ideal antifreezing compound is one that will prevent freezing of the radiator liquid without injuring either engine or radiator, that will not lose its nonfreezing properties after continued use, and that does not materially change the boiling point of water when dissolved in it.

A careful study of this question by the Bureau leads to the conclusions based on experiment that, (1) calcium chloride compounds should be used with caution, if at all, on account of their corrosive action; (2) kerosene or similar oils should not be used on account of their inflammability, high boiling point, and effect on rubber; (3) mixtures of glycerine and alcohol can be used, but the price of glycerine, and the need for it in the manufacture of munitions at the present time should preclude its use; (4) solutions made from either wood alcohol or denatured alcohol seem at the present time to be the most desirable antifreezing solutions to use. If the wood alcohol is free from acid there is little choice between the two alcohols. Wood alcohol costs more than denatured alcohol and is more volatile, but its lower freezing point allows a less amount to be used, which may counteract this disadvantage.

There are two general types of these compounds—one a solution in water of alcohol or glycerine, or of a mixture of the two latter, the other a solution in water of calcium chloride or the dry salt itself, which contains sometimes small amounts of other substances, such as salt, sal ammoniac, sugar or syrup. Kerosene and similar oils, without admixture, are sometimes used.

Kerosene has a lower freezing point and higher boiling point than water, but the inflammability of its vapor makes it dangerous to use, and its high and uncertain boiling point might lead to the serious overheating of the engine, or even to the melting of the solder in the radiator. It has a marked solvent action on rubber parts. These facts would seem to clearly indicate that this material should not be used.

The alcohol-water type is the most common and is not generally sold under any trade name, but recently there have appeared on the market a number of antifreezing compounds of the calcium chloride type. These compounds are sold under a variety of names, and startling claims are made for their effectiveness and lack of injurious effects.

Corrosive Action

The alcohol solutions do not exert a greater corrosive action than water alone. However, wood alcohol sometimes contains free acid, such as acetic acid, which is objectionable, and for this reason wood alcohol should be used only when it is known to be free from acids.

The calcium chloride compounds exert a greater corrosive action than water on the engine jacket, on the solder in the radiator and on aluminum which is sometimes used in manifolds, pumps and headers. The effect on engine jackets may be neglected since these are in general sufficiently heavy to permit considerable corrosion without being weakened. The effect on soldered joints may be serious, since tests made at the Bureau of Standards have shown the complete removal of solder from copper and brass when immersed in a hot 20 per cent calcium chloride solution for four days.

Calcium Chloride and Ignition

Another troublesome effect of calcium chloride solutions is experienced if small leaks occur in the radiator, the water jackets, or connections, and the solution comes in contact with the spark-plugs and ignition wires. In some cases the drops of the solution may be carried back on the engine in a more or less atomized state, assisted by the fan when running. The salt deposited when the water evaporates is very difficult to remove and when it cools absorbs water and becomes a good electrical conductor, short-ciruiting the spark-plugs and sometimes making it impossible to start the engine.

There are also certain conditions in the manufacture of calcium chloride which may result in a compound that will deposit large crystals in the radiator as the solution cools; this may prevent effective circulation.

Calcium Chloride Has Been Used

Regardless of these objections, reports have been received to the effect that calcium chloride solutions have been used a number of years in the same radiator without producing apparent corrosion. Nevertheless, such solutions cannot be recommended as safe, and they should not be used if there is any aluminum in the cooling system.

The chief advantage of calcium chloride compounds is that they are not volatile. The solutions can be kept practically uniform by adding water from time to time. Unfortunately this is not true with the alcohol solutions, because the alcohol continually boils out and it must be replaced frequently in order to maintain the proper proportion of alcohol. Glycerine is frequently substituted for part of the alcohol to reduce evaporation, but when glycerine is used the rubber connections may be affected somewhat seriously, depending on the quality of the rubber.

Price of Compounds

The price of these compounds is of decided interest. The retail price of denatured alcohol is more or less definitely fixed by its cost of production and the prevailing market conditions. Calcium chloride is a by-product from certain manufacturing industries and is sold at less than two cents per pound, wholesale. However, when properly packed and labeled it is sold to automobile users as an antifreezing compound at the rate of twenty-five to fifty cents per pound, an increase of between 1000 to 2000 per cent.

Without approving the use of a calcium chloride solution as an antifreezing solution it may be said that a home-made solution of calcium chloride can be prepared at a cost less than one-half the retail price at which such antifreezing compounds are sold, by buying calcium chloride in the open market and dissolving it in water.

STANDARD DIMENSIONS FOR MAGNETOS

ARE standards an asset? Progressive engineers and manufacturers are using them more and more, salesmen and consumers find them of ever-increasing value in distribution and use, and service enterprises are demanding them because standards permit of better service.

Why He Uses Standards

A prominent engine manufacturer recently said, "If you are not using standards, the sooner you do, the better off you'll be," and related his experience:

A few years ago, before standards were used to any material extent, he personally supervised the designing of his engines. When it came to providing magneto space and dimensions on a layout, there was no uniform practice that could be adopted. It was necessary to secure catalogs and drawings from each maker of the magnetos he wanted to consider, and there was always delay in getting the needed information, which held up the engine drawings for some time. After the data were secured, it took time to determine which magneto he would use. After the decision was made he had to rely on one magneto manufacturer to supply him, because other instruments would not fit his design without expensive alterations and still further delays.

As the selection could not be left to a layout man, he was obliged to spend much time on details when he was needed on more important work.

Magneto dimensions insuring interchangeability of makes have since been standardized and adopted so that today this engineer can devote his time and energies to more important problems. He simply tells his layout men, "Go ahead and use S. A. E. Standard Magneto Dimensions."

The Standard

The S. A. E. standard for magnetos is published in Data Sheet form for distribution to manufacturers and users. It has been extensively adopted by magneto manufacturers and approved for aeronautic, automobile, marine, motorcycle, stationary and farm engine, tractor and truck installations.

The standard embodies:

1 Maximum over-all space required.

2 Location and size of hold-down bolts.

3 Height of shaft-center above the base.

4 Dimensions of shaft-end taper and the nut-thread dimensions.

5 Dimensions of engine driving-shaft end.

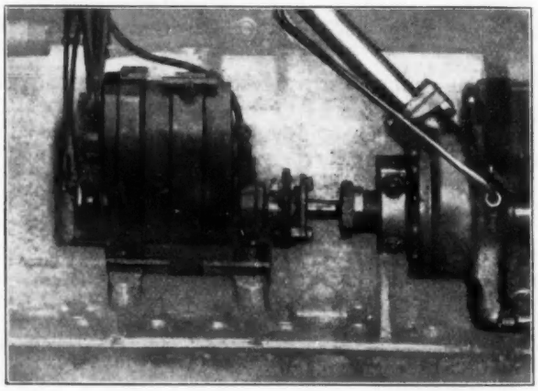
6 Location of magneto base and shaft-end with respect to engine driving-shaft end.

7 Advance lever radius, and sizes of plain and tapped holes in the timing lever.

Why the Standard Is an Asset

The use of the S. A. E. Standard Magneto Dimensions is an asset because the designing engineer can build this standard into the powerplant and use practically any magneto desired, whether the powerplant is to work on water, land or in the air. The standard conforms to the best general engineering practice, as determined by engineers experienced in the industry, and furnishes the draftsman with the required detail information.

When standards are used, the manufacturer can obtain necessary supplies of materials and parts with less difficulty and at lower cost. He can also simplify tool equipment and reduce the cost of plant operation, and expense for labor, machinery and materials. Labor becomes more highly skilled, insuring a better grade of production. Production problems are simplified and output will move faster and more easily, insuring more dependable deliveries.



A Typical Magneto Installation

The salesman can offer a product embodying the best accepted engineering practice, broadening the possibilities of advertising and reaching into a larger market. At the same time the confidence that he and his customers have in the product is strengthened.

The customer is assured that the equipment purchased will give the best possible return on the investment, and that standards mean better quality, lower costs, proper operation and satisfactory service. The service man can reduce his burden in stock and investment and give better service to his customers at less expense and with the least delay.

Information regarding S. A. E. Standards is available in ready reference form. The Society is cooperating with both manufacturers and users by answering requests for information promptly.

A PUNCH IN EVERY BOND

THE Central Powers have sought to conquer the world through military force, so that their masters might have glory and greater power and feed their greed on the spoils of the conquest. The only argument against this course which the Kaisers understand is force, and the United States is giving them that answer. Force means men and supplies and money—much money.

The Government asks us to take up the Fourth Liberty Loan, a tremendous sum, but all of it needed to carry on our war program. Our force is not to be applied to serve greed, but for self-protection and self-preservation. Our money could not be devoted to a better purpose. All that we believe in as right and desirable and good and holy hangs in the balance. Our men at the front and our dollars at home will turn the scales in our favor. We must buy bonds now—buy all we can pay for by saving and sacrifice, so that our country may win the victory which we all expect.

Current Standardization Work

STANDARDS ADOPTED BY LETTER BALLOT

THE 44 recommendations submitted at the June meeting of the Society and approved for final presentation to the voting members of the Society were adopted in their entirety by the letter ballot which closed on the 16th of August.

The reports on which this action was taken were printed in THE JOURNAL of the Society last July, but certain minor corrections were found necessary. These were incorporated in the letter ballot and are given in the result of the vote below.

The only considerable number of negative votes was registered against the first subject in the report of the Data Sheet Division. It is believed, however, that this was due to the way in which the report was worded. The advantages of a larger size sheet were given first, but the actual recommendation of the Division was that the present size of the data sheet should be retained permanently, and this action has been adopted as a result of the letter ballot. The complete vote on the recommendations is given below.

REPORT OF AERONAUTIC DIVISION

	Yes	No	Not Voting	Blank
1 Turnbuckles	102	1	118	38
2 Loops for non-flexible single-strand steel cable	97	0	125	37
3 Aircraft bolt-head and nut dimensions	106	1	115	37
4 Aircraft screws and bolts—diameter limits	106	1	115	37
5 Aircraft bolts—thread pitches	106	1	115	37

REPORT OF BALL AND ROLLER BEARINGS DIVISION

	Yes	No	Not Voting	Blank
1 Annular ball bearings (It is recommended that these tolerances become effective Jan. 1, 1919)	154	0	67	38
2 Standard temperatures for measurements	150	1	71	37
3 Definition of eccentricity	152	0	70	37
5 Thrust bearing tolerances (On page 97, July issue, THE JOURNAL, under "Double Direction Thrust Bearings—With Self-Aligning Washer" in the table of Diameter (D), inch sizes, 5.9448 should be 5.9449)	151	0	72	36

REPORT OF DATA SHEET DIVISION

	Yes	No	Not Voting	Blank
1 New size of data sheets	140	48	37	34
2 New sheet numbering system	182	8	32	37
3 Classified sectional index	193	1	30	35
4 Woodruff key tables	194	0	31	34
5 Curve sheets	191	0	33	35
6 Transferring data sheets	185	3	34	37
7 Data sheet revision	184	2	35	38

REPORT OF ELECTRICAL EQUIPMENT DIVISION

	Yes	No	Not Voting	Blank
1 Starting motor pinion	155	1	74	29
2 Starting switch location	147	4	79	29
3 Marking of fuses	161	0	71	27
4 Ignition distributor mounting	155	0	72	32
5 Flange mountings for starting motors (Size Nos. 2 and 3)	156	1	71	31
6 New flange mounting for starting motors (New size No. 1)	158	0	70	31
8 Generator shaft-end for coupling drive	161	1	67	30
9 Cable lengths and terminals for starting motors	148	0	78	33
11 Bracket mounting for generators	142	0	70	47

REPORT OF ENGINE DIVISION

	Yes	No	Not Voting	Blank
1 Hand starting-cranks	149	6	73	31
2 Magneto drive-shaft and coupling dimensions	167	1	60	31
3 Thermostat connections	143	1	78	37

REPORT OF TIRE AND RIM DIVISION

	Yes	No	Not Voting	Blank
1 Pneumatic tire sizes—passenger cars and commercial vehicles	136	1	91	31
2 Rim sections and contours, passenger cars and commercial vehicles	125	1	100	33
3 Valve-hole size, automobile rims	127	1	100	31
NOTE: In the fourth line omit *"inclusive."*				
4 Valve-hole size, motorcycle rims	106	1	119	33
5 Carrying capacities, inflation pressures, for automobile pneumatic tires	125	2	99	33

6 Motorcycle tire capacities and pressures 102 2 122 33

The Tire and Rim Association on July 12, 1918, in Cleveland adopted the following motorcycle tire capacities and inflation pressures, these now being adopted also by the Society.

Tire Size	Max. Load (Lb. per Tire)	Corresponding Inflation Pressure (Lb. per Sq. In.)
2¼	175	35
3	325	40
3½	400	45

7 Deflection and set test of rims for automobile pneumatic tires 121 1 101 36

8 Wood felloe dimensions, pneumatic tire rims.....122 1 105 31

10 Edge of felloe bands.....123 1 105 31
(On page 106, second paragraph, second line, *chamber* should be *chamfer*)

11 Allowable tolerance in felloe bands 113 1 107 38

12 Wood spoke dimensions, commercial vehicle wheels....117 1 104 37
(In the illustration, the dimension ½ in. should be 1½ in. In the table, the first number in column *K* is 3½ in.)

REPORT OF TRACTOR DIVISION

1 Speed and widths for power belts and pulleys.....125 0 91 43

2 Screws and bolts.....139 0 82 38
(On page 109, third paragraph, fourth line should read ". . . ⅛ *in. steps above ½ in. diameter*")

3 Carbureter flanges 138 2 80 39

4 Use of existing standards...137 0 80 40

5 Complete specification form.144 1 77 37

SCREW THREAD COMMISSION ORGANIZED

A MEETING of the Government Commission for the Standardization of Screw Threads was held Sept. 12 and 13 at the Bureau of Standards, Washington. This meeting was largely for the purpose of organization, since the members of the Commission had not then been formally appointed by the Secretary of the Department of Commerce. The nominations of the various members have now all been made, however, and it is understood that the commission will be composed as follows:

Chairman, Dr. S. W. Stratton, Director of the Bureau of Standards.

Army Representatives: Lieut. Col. E. C. Peck (M. S. A. E.), Ordnance Dept., U. S. A., and Major O. B. Zimmerman, Engineer Corps, U. S. A.

Navy Representatives: Commander S. M. Robinson, Bureau of Steam Engineering, Navy Department, and Commander E. J. Marquart, Bureau of Ordnance, Navy Department.

As stated in the last issue of THE JOURNAL, the civilian members will be Edwin H. Ehrman and H. T. Herr, for the S. A. E., and James Hartness and F. O. Wells, representing the American Society of Mechanical Engineers.

The commission in doing its work will require a huge amount of data regarding present practice. In order to obtain this, the Bureau of Standards late in August sent out a questionnaire to several thousand engineers and others interested in the manufacture of screw threads in this country. It was reported that over a thousand replies had been received. The questionnaire is intended to obtain information as to the most productive activities that can be undertaken by the commission and also as to the manufacturing practices now followed in making screw cutting tools, and also parts using threads.

The Bureau has also prepared a description of the more important systems of screw threads, in this and foreign countries, used primarily to fasten parts of machines. This was gathered for the preliminary information of the commission and will be supplemented later by summaries of the answers returned to the questionnaire. At the meeting itself, the sort of information that ought to be considered by the commission was discussed, and it was decided that statistics should be collected concerning carriage bolts, screws and bolts used in agricultural machinery, machine tools, and screw standards employed by die makers as well as by instrument makers and others. Photographs and samples of screw threads and of machines in which they are used are also to be collected.

The need of international screw-thread standardization was emphasized and a letter was read from Mr. C. le Maistre, secretary of the British Engineering Standards Association, requesting cooperation between the British and American committees working on screw-thread standardization. It was the sense of the meeting that such cooperation was highly desirable and that representatives of the British Engineering Standards Association now in this country should be requested to attend meetings of the commission in which international screw-thread matters are considered.

The work now being done by S. A. E. and A .S. M. E. committees on screw threads and nuts and also on tap and screw thread tolerances was mentioned, and it was the opinion that these activities should be continued and correlated with the work of the commission.

It was decided that the commission should be subdivided into committees as follows:

1 System, including questions relating to profile, pitch and diameter.

2 Classification, including questions relating to tolerances, allowances and nomenclature.

3 Gages and methods of testing, and specifications.

The statement was made by Dr. Stratton that the facilities of the Gage Section of the Bureau of Standards are at the disposal of the commission and that any tests required can be made there.

It is understood that H. W. Bearce, Division of Weights and Measures, Bureau of Standards, will act as secretary of the commission, and that Robert Lacy of the A. S. M. E. will serve as assistant secretary. H. L. Van Keuren, in charge of the Gage Section of the Bureau of Standards, Mr. Bearce and Mr. Lacy will act as secretaries to the above subcommittees.

CONSTITUTIONAL AMENDMENTS ADOPTED

THE tellers appointed by President Kettering to count the ballots sent in by the members last month have submitted to him the following report:

"The undersigned tellers appointed by you have examined the letter ballot cast in connection with the proposed amendments of Sections 5, 8, 13, 15, 20, 21, 22, 25, 26 and 45 of the Constitution of the Society of Automotive Engineers, Inc., these being amendments proposed and discussed at the Society meeting in January, 1918, and discussed and amended at the Society meeting in June, 1918. The amendments have been adopted by vote, as follows:

Total number of votes cast	338
Ballots favoring adoption of proposed amendments	332
Ballots not favoring adoption of proposed amendments	None
Ballots defective	6

(Signed) A. C. Bergmann,
Harold W. Slauson,
R. E. Plimpton."

The amendments are given below as adopted by the voting members of the Society.

Membership

C 5 is amended to read as follows:

The membership of the Society shall consist of Honorary Members, Members, Associates, Juniors, Departmental Members, Service Members, Foreign Members and Affiliate Members. Honorary Members and Members are entitled to vote and to hold office. Associates, Juniors, Departmental Members, Service Members, Foreign Members and Affiliate Members shall not be entitled to vote or to be officers of the Society but shall be entitled to the other privileges.

C 8 is amended to read as follows:

Member grade shall be composed of persons 26 years of age or over, who by previous technical training or experience or by present occupation are qualified to act as designers or constructors of complete automotive apparatus or their important component parts; or to exercise responsible technical supervision of the production of materials germane to the construction of automotive apparatus; or to take responsible charge of automotive engineering work; or to impart technical instruction in the design and construction of automotive apparatus; or who by reason of distinguished service or noteworthy accomplishment would, in the discretion of the Council, appear to be desirable additions to this grade.

Service Member grade shall be composed of persons 26 years of age or over, engaged exclusively by the United States Government, the qualifications for this grade being the same as those for Member grade.

Foreign Member grade shall be composed of persons 26 years of age or over, resident in countries other than the United States, Canada, Mexico or Cuba. The qualifications for this grade shall be the same as those for Member grade.

A Member who has become eligible for either the Service Member grade or the Foreign Member grade, may upon written request be transferred to such grade and thereafter, beginning with the next fiscal period, shall pay the annual dues for said grade.

C 13 is amended to read as follows:

The rights and privileges of every Honorary Member, Member, Associate, Junior, Service Member and Foreign Member, shall be personal to himself and shall not be transferable by his own act or by operation of law. Departmental Membership and Affiliate Membership also shall not be transferable.

Admission

C 15 is amended to read as follows:

All original applications for election to the grade of Member, Associate, Junior, Service Member or Foreign Member, shall be presented to the Council, which shall consider and act upon each application, electing each applicant to the grade of membership to which, in its judgment, his qualifications entitle him. Two negative votes shall defeat an election.

Initiation Fees and Annual Dues

C 20 is amended to read as follows:

The initiation fee for membership in each grade and for Student Enrollment shall be as follows:

For Member	$25.00
For Associate	25.00
For Junior	10.00
For Service Member	10.00
For Foreign Member	10.00
For Student Enrollment	None
For Departmental Member	100.00
For Affiliate Member	50.00

C. 21 is amended to read as follows:

The annual dues for membership in each grade and for Student Enrollment shall be as follows:

For Member	$15.00
For Associate	15.00
For Junior	5.00
For Service Member	10.00
For Foreign Member	10.00
For Student Enrollment	3.00
For Departmental Member	None
For one Affiliate Member Representative	15.00
For each additional Affiliate Member Representative	10.00

C 22 has the following added thereto:

A Service Member shall upon the termination of his connection with the Service promptly notify the Secretary of such termination, shall then be transferred to Member grade, and shall pay the difference in initiation fee between that specified for Member in C 20 and the actual amount paid by the Service Member at the time he qualified, and thereafter, beginning with the next fiscal period, shall pay the annual dues for Member grade.

A Foreign Member shall notify the Secretary upon change of residence to territory rendering him ineligible for Foreign grade, or temporary change of abode to such territory for more than six months in a given fiscal period, and shall thereupon be transferred to Member grade, and shall pay the difference in initiation fee between that specified for Member in C 20 and the actual amount paid by the Foreign Member at the time he qualified, and thereafter, beginning with the next fiscal period, shall pay the annual dues for Member grade.

Suspensions and Expulsions

C 25 is amended to read as follows:

Any Member, Associate, Junior, Service Member, Foreign Member or Affiliate Member who shall leave the annual dues unpaid for three months shall not receive any publications of the Society until such dues are paid.

Any Member, Associate, Junior, Service Member, Foreign Member or Affiliate Member who shall leave the dues unpaid for one year shall, in the discretion of the Council, cease to have any further rights in the Society and be stricken from the rolls of membership. The resignation of a member whose account with the Society is not fully settled can be accepted only by vote of the Council.

C 26 is amended to read as follows:

The Council may temporarily suspend the annual payment of dues by any Member, Associate, Junior, Service Member or Foreign Member whose circumstances have become such as to make it impossible for him to pay the dues, and may, under similar circumstances, waive the whole or part of dues in arrears. Such action shall be taken only on the written application of the Member, Associate, Junior, Service Member or Foreign Member, signed by three other members in good standing, or upon the submission of evidence satisfactory to the Council that the action is for the best interests of the Society.

ADMINISTRATIVE COMMITTEES

C 45 is amended to read as follows:

The President shall, within thirty days after taking office, appoint, from the individual membership of the Society, the following Committees, designating the Chairmen thereof:

Finance Committee, consisting of five members.
Meetings Committee, consisting of five members.
Publication Committee, consisting of five members.
Membership Committee, consisting of five members.
House Committee, consisting of five members.
Sections Committee, consisting of five members.
Tellers as required by the By-Laws.

There shall be also a standing committee of the Society called the Constitution Committee, consisting of three members, one of whom shall be appointed by the President within thirty days afer taking office, for a term of three years. The member who shall have but one year yet to serve shall be the chairman.

COTTON FABRIC FOR AIRPLANES

ACCORDING to a statement issued by the War Department, the production of American cotton airplane fabric is now averaging about 1,200,000 yards monthly, sufficient for all requirements, and capable of being largely increased, if necessary. No more linen fabric is being imported from abroad for this purpose, and after the imported stock now on hand is exhausted cotton fabric will be used exclusively in covering American airplane wings.

At the outbreak of the war, in 1914, linen was the only material which had proved entirely satisfactory for covering airplane wings, the essential physical properties required being lightness in weight, proper absorption of dope, and strength and resistance to tear.

The chief countries before the war producing flax for fine grades of linen were Belgium, Russia and Ireland. The Belgium supply was cut off from the Allies in 1914. The Russian flax was difficult to obtain, and was later cut off entirely. In the meantime, the consumption of linen for war purposes had increased enormously. By the spring of 1917, when the United States entered the war, the linen situation was serious, and it was obvious that some substitute would have to be found.

In developing a cotton airplane fabric which would have the essential qualities of the linen the United States Government received the greatest assistance from the various cotton mills.

Samples were made from cotton of many constructions and numbers of yarn, varying from No. 40 two-ply to No. 100 four-ply, the cloth having from 50 to 90 threads per inch. Yarns were in some cases mercerized under tension and various twists were tried. Several cotton mills cooperated in this work.

When the new fabrics were secured, samples were put on airplanes, "doped," and varnished, according to regulation practice, and tested in actual use at Langley Field and Pensacola. Flying tests were also made with several other varieties of fabric. The tests were for three months of service, averaging ten hours per day. Members of the United States Air Service, members of the foreign flying corps, and other experts, assisted in the experiments. They reported that the cotton fabrics developed in the United States appeared to serve admirably. Other favorable reports have recently been received from tests made in Great Britain on American cloth sent over there.

After many experiments had been made, the first contracts for 10,000 yards each of cotton airplane fabric were placed in September, 1917. The results obtained with the first fabric produced were satisfactory, and it was decided to place further contracts.

Two fabrics were adopted, the specifications calling for a strength of not less than 80 lb. per in. in both warp and filling. The cotton used in the manufacture of the fabric had to be of a long staple, and in November, 1917, the Air Service purchased 15,000 bales of long staple Sea Island cotton.

The first quantity orders were placed in October and November, 1917, and were for 1,280,000 yards of grade A and 200,000 yards of grade B. Deliveries started in January with the production of 173,000 yards. Production has gradually increased until at the present time 1,200,000 yards are being produced monthly.

Subsequent contracts have been let amounting to 11,513,084 yards. All of these later contracts, however, have been for grade A cotton fabric, as it now seems clear that this cloth is superior to the other.

While the cotton airplane fabric was at first used for training planes only, and the grade A standard linen fabric, imported from Great Britain, was used for combat planes, it was decided in April, 1918, that grade A cotton fabric could be used for all types of planes.

Activities of S. A. E. Sections

MOST of the Sections will start their work in October, although Cleveland and Detroit held meetings in September, the former on the 19th and the latter on the 20th. The speaker at each meeting was the President of the Society, Mr. C. F. Kettering. He was greeted by large and enthusiastic audiences in both Cleveland and Detroit. Mr. Kettering's remarks dealt with the aircraft situation as regards its present military significance and in respect to the possibilities of after-the-war use. In Detroit he gave an interesting account of the fundamentals underlying aircraft design and concluded his address by urging the importance of presenting high-grade technical papers at Society and Section meetings. President Kettering's remarks at the two meetings will appear in the next issue of THE JOURNAL.

The Buffalo Section will be responsible for presenting four papers during the year at meetings of the Buffalo Engineering Society. The first of these meetings will take place on the 23rd of October. The Metropolitan Section has made arrangements for early meetings on highway transport, aircraft construction and hydraulic-transmission subjects. The Mid-West Section participated in the Oct. 11 meeting of the War Committee, Technical Societies of Chicago, which was addressed by Col. Peter Junkersfeld of the Quartermaster Corps on the subject of emergency construction for the U. S. War Department.

The first meeting of the Minneapolis Section was held October 2, W. G. Clark giving a paper on Prevailing Types of Air Cleaners. The plans of the other Sections are in a formative state.

The outline of the Detroit activities given below is extremely interesting as showing how the Detroit members are going ahead in making full use of the opportunity for service now afforded by Section meetings.

DETROIT SECTION ORGANIZATION, 1918-19

By Chairman J. Edward Schipper

Prospects for a profitable season in the Detroit Section are remarkably good. Detroit is the center of the automotive manufacturing belt, and the war work in the city and its immediate vicinity reaches the remarkable total of over two billion dollars, so that conditions, from the automotive engineering point of view, particularly, favor a highly successful season.

The great influx of engineers and production men into this field, due to war work alone, opens up a prospect for increased membership. The demands for skilled men in this territory are so great that a steady flow from all parts of the country is finding its way into the factories which for years have been in the automobile industry, and into the even greater factories which have sprung up with mushroomlike rapidity since the United States entered into the world conflict.

With the Section administration pledged to the policy of bringing before the Section speakers informed to the highest degree in matters pertaining to the vast production schedule now being met by our factories, it is inevitable that attendance at meetings will be consistent with the effort expended in war work.

A phase of engineering and industrial thought which will not be overlooked by the Detroit Section during this coming season is that of "Preparedness." Three years ago preparedness meant getting ready for war; today preparedness means getting ready for peace. This country at present is just as unprepared for peace as it was unprepared for war three years ago. Stimulating preparedness along this line is part of the Section program.

With a membership nucleus of over 1200 at the beginning of the present season, it is thought by the officers of the Section that the biggest men in their respective fields will be willing to bring their ideas before this organization. With this in mind, the Meetings Committee has scheduled a list of prospective speakers which would do credit to any engineering organization, and particularly one so closely bound up with the industrial future.

The opening meeting was addressed by C. F. Kettering, president of the Society. Other speakers will be announced by the Section well in advance of the meetings. Members of the parent body, whether members of the Section or not, are cordially invited to attend the Section meetings whenever they are in the vicinity of Detroit. Members of other engineering organizations, and those having any active interest in the automotive industries, are urged to attend the meetings of the Detroit Section.

TRANSPORT COMMITTEES WORKING IN EVERY STATE

THE manner in which the great power of the United States in the way of materials, men, money and commodities is being put into the struggle against the Central Powers is reflected in a most graphic way in the operation of the Highways Transport Committees of the various State Councils of Defense, the activities of these highway transport bodies being directed toward conservation of the potential power of the Nation through the strengthening of its transportation facilities.

In New York, Pennsylvania, Michigan, Illinois and others of the large states, the store-door-delivery plan is now being studied in the most intensive way. In these states, as well as in Connecticut, Massachusetts, Maryland, Alabama, Kentucky, West Virginia, Ohio, Missouri and California, the material aid to the Government which may result from the organization of rural express lines, return-load bureaus and cooperation with the Federal Railroad Administration, is being impressed upon the public to such an extent as to produce gratifying results.

The prosecution of the war during the coming year in the manner indicated by the President in his proclamation fixing a standard price for wheat, directs the attention of the country unerringly to agricultural conditions which may prevail in 1919, and demands the conservation of every possible source of strength.

The daily reports of rural express lines now in successful operation in the different states show concrete results in the way of conservation of man power in the field, and this spells more and better food on the front in France, on the transports at sea, and in the millions of homes of the United States and its Allies.

The store-door delivery plan recently put into effect in New York City, with the approval of Director General of Railroads McAdoo, and under the personal direction of Commissioner J. S. Harlan of the Interstate Commerce Commission, means that the great terminals around New York will be emptied more quickly and congestion averted to a large extent during the coming winter.

PERSONAL NOTES OF THE MEMBERS

W. D. Appel, formerly motor engineer, The Steel Products Co., Cleveland, is now in the engineering department of the Curtiss Engineering Corp. of Garden City, Long Island, New York.

Blood, Wallace B., formerly manager, Wallace B. Blood Automotive Service, Chicago, is now technical advertising advisor with The Carl M. Green Co., Detroit.

P. C. Christman, formerly vice-president, general manager and treasurer, Gill Piston Ring Co., New York, is no longer with that company.

Clarence M. Day, formerly president, Perlman Rim Corp. of New York, and Jackson Rim Co. of Jackson, Mich., is now president of the Jaxon Steel Products Co., Jackson, Mich.

F. G. Diffin, formerly chairman, International Aircraft Standards Board, Washington, is located at 52 Vanderbilt Ave., New York.

T. Randall Du Bois, formerly engineer, Bijur Motor Lighting Co., Hoboken, N. J., is now with the U. S. Light & Heating Corp. of Niagara Falls, New York.

David T. Eighmey, formerly engineer, Campbell Motor Car Co., Kingston, New York, is now with the Wright-Martin Aircraft Corp., Long Island City, New York.

W. B. Engler, formerly mechanical development engineer, The Crown Cork & Seal Co., Baltimore, is no longer with that company.

F. M. Germane, formerly general manager, Standard Roller Bearing Co. of Philadelphia, has now been appointed director of sales in the same company.

Hugh C. Gibson, formerly automotive purchasing agent for the British War Mission in New York, is now consulting engineer in New York.

B. D. Gray, formerly major, U. S. R., has been called into service in the War Department, Bureau of Aircraft Production, where he will be in full charge of the manufacture of Hispano-Suiza engines. These engines are to be put out at 150, 180 and 300-hp. ratings, the Wright-Martin Company, New Brunswick and Long Island City, the Pierce-Arrow Company of Buffalo and the H. H. Franklin Company of Syracuse, N. Y., taking the bulk of the work, although several hundred subcontractors will be engaged in making major and minor parts. Mr. Gray will be responsible for all matters of engineering, production and inspection.

Herbert A. Hansen, formerly in purchasing department, The Holt Mfg. Co. of Peoria, Ill., is now chief draftsman with the C. L. Best Gas Traction Co., San Leandro, Cal.

A. S. Heinrich, president and chief engineer of the A. S. Heinrich Corp. of Freeport, Long Island, New York, has had the name of this company changed to the Victor Aircraft Corp.

Charles G. Keller, formerly engineer, Robeson Cutlery Co., Perry, New York, is now production engineer of the Savage Arms Corp. in Sharon, Pa.

Thomas J. Litle, Jr., engineer of the Lincoln Motor Company, Detroit, Michigan, has been appointed a member of the Welding Research Committee of the Emergency Fleet Corporation, U. S. Shipping Board. Mr. Litle has been closely investigating both gas and electric welding conditions in the American plants constructing Liberty engines, and his appointment will be helpful in effecting an interchange of data between the aircraft and shipbuilding industries. This appointment does not affect Mr. Litle's connection with the Lincoln Motor Company.

L. Z. McKee, formerly sales manager, Oklahoma Auto Mfg. Co., Muskogee, Okla., is now sales manager, Brooklyn branch of the Sterling Tire Corp., Brooklyn, New York.

A. E. Patchin, formerly sales manager, Pan-American Motors Corp., Decatur, Ill., is now general sales manager, The Dependable Truck & Tractor Co., Galesburg, Ill.

H. F. Peavy, formerly engineer, Locomobile Co. of America, Bridgeport, is now assistant engineer, Mercer Automobile Co., Trenton, New Jersey.

J. G. Perrin, formerly aeronautical mechanical engineer, Signal Corps, U. S. A., is now assistant manager, Aircraft Division, Willys-Overland, Ltd., W. Toronto, Canada.

G. S. Porter, formerly with the Jackson Rim Co. of Jackson, Mich., is now with the Jaxon Steel Products Co., Jackson, Mich.

N. G. Rost, general sales manager, Duesenberg Motors Corporation, is now making his headquarters at the Washington office of that organization, which has recently opened in the Munsey Building.

G. A. Sanford, formerly sales engineer, Jackson Rim Co. of Jackson, Mich., is now sales manager, rim division, of the Jaxon Steel Products Co., Jackson, Mich.

Wagoner, P. D., formerly president, General Vehicle Co. of New York, is now president of the Elliott-Fisher Co., Harrisburg, Pa.

John W. Watson, president of the American Bronze Corp., has recently been appointed assistant to Mr. B. D. Gray, Production Department of the Bureau of Aircraft Production, War Department, U. S. A., in carrying out the Government program for the production of the Hispano-Suiza aircraft engines. Mr. Watson will be stationed in the New York District Office, 480 Lexington Avenue.

Honor Roll of Society Members

THE following members have recently entered the services of the government in civilian or military capacities. This list, together with the "Service Directory of Members," which will be printed in the JOURNAL from time to time, is intended to contain the names of all members connected with the government, either in the military service or in civilian capacities. The names are listed in two parts, the first showing the members who have actually entered the military services, and the second those engaged as civilians. Every effort is made to have the addresses correct. It is therefore requested, in case of any error, that the member concerned immediately inform the New York office of the Society, so that proper correction can be made. Members who have actually entered the service in any capacity, and who are not listed, should also write the details to the New York office.

MILITARY

Ames, Azel, major, Coast Artillery Corps, N. G., France.

Bacon, Charles V., captain, manager of technical and research departments, Engineer Corps, Division of Investigation, Research and Development, (mail) General Engineering Depot, 1438 U St., Washington.

Bridge, Robert B., Air Service, U. S. A., Aircraft Acceptance Park, Phase 2, A. E. F., France.

Case, George S., major, Chemical Warfare Service, U. S. A., Washington.

Franks, J. B., Jr., lieutenant, Motor Transport Service, U. S. A., P. O. 717, A. E. F., France.

Goldsborough, Paul, captain, Aviation Section, Signal Reserve Corps, (mail) Carlstrom Field, Arcadia, Fla.

Good, John, lieutenant, U. S. N. R. F., New London, Conn.

Haskell, A. G., Quartermaster Corps, N. A., (mail) Mechanical Repair Shop Unit 302, Co. 4, A. E. F., France.

Heaslet, James G., major, Bureau of Aircraft Production, 1550 Woodward Ave., Detroit, assigned as district manager of production.

Higginbotham, P. R., captain, 8th H. M. O. R. S., Camp Hancock, Ga.

Hill, Nestor Francis, second lieutenant, Mechanical Repair Shop Unit 306, Motor Transport Corps, Camp Holabird, Md.

Johnson, Courtney, lieutenant, 51st Brigade Field Artillery, U. S. R., A. E. F. via New York.

Kerr, C. P., Air Research Division, Aviation Section, Signal Corps, A. E. F., France.

Knepper, F. B., second lieutenant, Co. A, 507th Engineers, Engineer Reserve Corps, A. E. F., France.

Lonn, Julius M., captain, inspection officer, Ordnance Reserve Corps, U. S. A., (mail) Frankford Arsenal, Philadelphia.

Marx, Frank W., Co. K, Ft. Sheridan Training Camp, Ft. Sheridan, Ill.

Moffatt, James, cadet, Aviation Section, Signal Corps, N. A., (mail) Barracks 52, Kelly Field 2, San Antonio, Texas.

Overlock, R. F., Unit S, Co. 914, U. S. Naval Operating Station, Hampton Roads, Va.

Ozias, Glenn M., 231st Aero Squadron, Post Field, Ft. Sill, Okla.

Redin, Paul H., 21st Co., 161st Depot Brigade, Camp Grant, Ill.

Roberts, W. Saunders, First Battery, Reserve Officers Training Camp, Ft. Myer, Va.

Rowe, Samuel E., master signal electrician, 821st Aero Squadron, Speedway, Indianapolis.

Stalnaker, W. E., major, Ordnance Department, U. S. A., Indianapolis.

Taylor, W. F., captain, 150th Field Artillery, A. E. F., France.

Van Dam, Loring, ensign, U. S. N. R. F. (mail), Bureau of Ordnance, Navy Department, Washington.

Wood, William G., Jr., corporal, Co. B, 307th Supply Train, A. E. F., France.

Woodall, Herbert J., U. S. S. Decatur, Postmaster, New York.

CIVILIAN

Bauer, Louis E., district manager of production, Bureau of Aircraft Production, Dayton.

Beasley, W. F., chief draftsman, Engineering Division, Motor Equipment Section, Ordnance Department, Washington.

Consoliver, E. L., chief instructor in starting, lighting and ignition division for automobile mechanics, University of Wisconsin Army School, Madison, Wis.

Fox, Elmer D., draftsman, Research Division, Airplane Engineering Department, U. S. A., Mutual Home Bldg., Dayton.

Prince, Louis A., chief special mechanic, U. S. N. R. F. C., Barracks 315, Philadelphia Navy Yard, Philadelphia.

Schultheis, Everett M., inspector, Signal Corps, U. S. A., Nordyke & Marmon Co., Indianapolis.

Smith, G. W., chief of inspection, Detroit district, Motor Transport Service, Quartermaster Corps, N. A., Nook Bldg., Detroit.

Soulis, Harold A., mechanical engineer, Loading Section, Production Division, Ordnance Department, N. A., Washington.

Stevens, C. C., chief draftsman, Ordnance Department, U. S. A., Engineering Station, Bergen & Kearney Aves., Jersey City, New Jersey.

Tilt, Albert, naval constructor, Bureau of Construction and Repair, U. S. Navy, Washington.

Todd, Percy F., Engineering Department, Bureau of Aircraft Production, Detroit.

Applications *for* Membership

The applications for membership received between Aug. 15 and Sept. 18, 1918, are given below. The members of the Society are urged to send any pertinent information with regard to these names which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ADAMS, WALTER O., plant manager, Erie Specialty Co., *Erie, Pa.*

ALTREE, ARTHUR H. D., sales manager, assistant treasurer, Bosch Magneto Co., *New York.*

AMORY, JOHN HULL, sales manager, Auto Lubricants Dept., Jos. Dixon Crucible Co., *Jersey City.*

ANDERSON, W. K., aeronautical mechanical engineer, Production Engine Department, Bureau of Aircraft Production, *Washington.*

BAILEY, CHARLES A., sales manager, George D. Bailey Co., *Chicago.*

BERNING, WALTER W., chief laboratory instructor, Univ. of Cin., *Cincinnati.*

BEUTEL, ROBERT, designer, International Motors Co., *New York.*

BIGLEY, FRANK A., heat treating inspection foreman, Nordyke & Marmon Co., *Indianapolis.*

BROWN, CHARLES TURNER, patent attorney, 127 N. Dearborn St., *Chicago.*

BROWN, PHELPS, president, Witherbee Igniter Co., *Springfield, Mass.*

BURGESS, WALTER B., assistant production manager, Midland Motor Car & Truck Co., *Oklahoma City, Okla.*

BURTNETT, EVERETT R., 5912 Woodlawn Avenue, *Los Angeles, Cal.*

BYRON, O. E., chief engineer, Lee Loader & Body Co., *Chicago.*

CARRITTE, J. P., general manager, treasurer, McAdamite Aluminum Co., *Detroit.*

CATO, JOSEPH L., aeronautical experimental engineer, L. W. F. Engineering Co., Inc., *College Point, L. I., New York.*

CHAMBERS, W. IRVING, captain, U. S. Navy, *Washington.*

CLARK, C. C., manager, Chicago Office, American Bronze Corp., *Berwyn, Pa.*

CLAUS, W. M., assistant to service manager, Buick Motor Co., *New York.*

CROFOOT, CHARLES E., president, treasurer and general manager, Crofoot Gear Works, Inc., *Cambridge, Mass.*

DAVIS, ERNEST F., metallurgist, Willys Morrow Co., *Elmira, N. Y.*

DE LA MONTE, CHARLES H., experimental engineer, International Motor Co., *New York*

DICKEY, CLYDE E., president, treasurer, Dickey Steel Co., *New York.*

DUMOULIN, EDMOND, civil engineer, member of the Belgian Purchasing Commission of War Supplies in the United States, 25 Madison Ave., *New York*

ELIASON, R. O., mechanical draftsman, Engineering Division, Motor Equipment Section, War Department, *Washington.*

ENSIGN, WILLIAM, assistant to chief engineer, Midland Motor Car & Truck Co., *Oklahoma City, Okla.*

EWELL, ROBERT G., sales and adv. manager, Allen Motor Co., *Fostoria, Ohio.*

FELDINE, M., vice president, general manager, Menominee Electric Prod., Inc., and Lauraine Magneto Co., Inc., *New York.*

FISHBURN, O. E., assistant engineer, Chevrolet Motor Co., *New York*

FISHER, W. A., president, Fisher Body Corp., *Detroit.*

FLETCHER, ANDREW, JR., asst. to pres. & vice pres., W. & A. Fletcher Co., *Hoboken, N. J.*

FLINTERMANN, CARL H. L., active vice president, Detroit Pressed Steel Co., *Detroit.*

FOLEY, JOHN R., inspector electrical and mechanical equipment, Construction Div., Quartermaster Corps, *Detroit.*

FRANK, EDWARD D., sales manager, National Automatic Tool Co., *Richmond, Ind.*

FREER, RALPH, charge of planning and specification department, Machine Division, Paige Detroit Motor Co., *Detroit, Mich.*

FRENCH, W. F., general manager, Louisiana Motor Car Co., *Shreveport, La.*

FUJIWARA, TOSHIO, proprietor, Fujiware Shoten, *Tokyo, Japan.*

GOFFIN, JOSEPH F., inspector, Belgian Commission for the Purchase of War Supplies in the United States, *New York.*

GRIFFEY, BERNARD E., secretary, treasurer, Bernard E. Griffey Motor Supply Co., *Indianapolis.*

HAPPEL, A. W., chief draftsman, truck department, Willys Overland Co., *Toledo, Ohio.*

HARNETT, A. DE VERE, magneto designer, The Webster Electric Co., *Racine, Wisc.*

HARRIS, G. D., secretary, U. S. Tractor & Machinery Co., *Chicago.*

HECHT, E. A., chief mechanical draftsman, Mansfield Rubber Co., *Mansfield, Ohio.*

HEINZ, WILLIAM, instructor, War Education Dept., Univ. of Cin., *Cincinnati, Ohio.*

HIEGER, ROBERT H., mechanical engineer, Byrne, Kingston Co., *Kokomo, Ind.*

INGERSOLL, GEORGE BURT, chief draftsman, Engine Design Section, N. Y. District of Bureau of Aircraft Production, Duesenberg Motors Corp., *Elizabeth, N. J.*

JAMES, W. S., assistant physicist, Bureau of Standards, *Washington.*

JORDAN, RICHARD M., superintendent, Aircraft Production, Champion Ignition Co., *Flint, Mich.*

KELLER, EMIL E., president, Standard Screw Products Co., *Detroit.*

KENNEDY, D. DICK VANET, sales engineer, Perfex Radiator Co., *Racine, Wis.*

KENNEDY, DON F., metallurgical engineer, Hammond Steel Co., Inc., *Syracuse, N. Y.*

KERSHAW, ADOLPHUS L. first lieutenant, O. D., U. S. A., Engineering Division, Motor Equipment Section, *Toledo, Ohio.*

KIMMEL, FREDERICK C., president and general manager, Rochester Motor Co., *Rochester, N. Y.*

KING, FRANK, process engineer, Wright-Martin Aircraft Corp., *New Brunswick, N. J.*

KLEINERT, GEORGE H., plant manager, The Standard Parts Co., *Cleveland, Ohio.*

LAKIN, JOHN ROBERT, head of educational department, The Domestic Engineering Co., *Dayton.*

LANE, G. S., manager, The Westinghouse Air Spring Company, *Philadelphia.*

LAY, W. E., instructor in charge of automobile engineering, University of Michigan, *Ann Arbor, Mich.*

LEWIS, I. M., vice president, treasurer, manager, Bessemer Motor Truck Co., *Grove City, Pa.*

LYON, A. H., chief of tool and equipment design, Ingersoll Milling Machine Co., *Rockford, Ill.*

MCCONIGHEN, W. H., foreman, Kissel Motor Car Co., *Hartford, Wis.*

MCFARLAND, RAYMOND L., chief instructor training detachment, Iowa State College, *Ames, Iowa.*

MACKENZIE, DONALD, assistant physicist, Bureau of Standards, *Washington.*

MATHESON, ALEXANDER, instructor, Mass. Inst. of Tech., *Boston.*

MILLER, RAYMOND P., ensign, U. S. N. R. F., L. W. F. Eng. Co., *College Point, L. I., N. Y.*

MONGIARDINO, JAMES A. V., manufacturers' representative in foreign countries, Chipman Limited, 8-10 Bridge St., *New York.*

MORRISON, G. ELLIOTT, engineer, Breese Aircraft Corp., *Farmingdale, L. I., N. Y.*

MORSE, JOHN C., aeronautical mechanical engineer, Bureau of Aircraft Production, McCook Field, *Dayton.*

NEUBARTH, WILLIAM R., designer, Chevrolet Motor Co., *New York.*

NICHOLS, JOHN T., chief engineer, North American Motors Co., Pottstown, Pa., chief engineer and purchasing agent, Chadwick Engineering Works, *Pottstown, Pa.*

NISHIYAMA, FUMIO, military engineer, Tokyo Military Arsenal, *Tokyo, Japan.*

OSBORNE, W. F., staff engineer, The Texas Co., 17 Battery Place, *New York.*

OTTENJOHN, RALPH F., chief instructor engine tuning and carburetion, War Education Dept., Univ. of Cincinnati, *Cincinnati, Ohio.*

PAULSEN, CARLEY H., assistant inspector of Engineering Material, U. S. Navy, Curtiss Aero. & Motor Corp., *Hammondsport, N. Y.*

PLYM, FRANCIS J., president, manager, Kawneer Mfg. Co., *Niles, Mich.*

POWELSON, JOHN W., production engineer, Rochester Motor Co., Inc., *Rochester, N. Y.*

QUINN, JOHN LEWIS, district sales manager, Standard Oil Company, *Los Angeles, Cal.*

RAMSEY, ROBERT P., motor engineer, Kyle Smith Aircraft Co., *Huntington, W. Va.*

RENDALL, HAROLD G., draftsman, Mitchell Motors Co., Inc., *Racine.*

RICHARDSON, G. F., foreman, Marburg Brothers, Inc., 90 West St., *New York.*

ROBERTSON, MALCOLM H., salesman, Vacuum Oil Co., *Philadelphia.*

ROBINSON, HUGH A., general superintendent, Aeromarine Plane & Motor Co., *Keyport, N. J.*

ROOT, ORLANDO J., vice president, Root & Vandervoort Engr. Co., *East Moline, Ill.*

RUSSELL, HARTWELL B., draftsman, designer, Motor Transport Corps, Quartermaster Corps, *Washington.*

SCHUEHLE, WALTER A., aeronautical mechanical engineer, Signal Corps, McCook Field, *Dayton.*

SCOTT, WALTER M., secretary, general manager, Sterling Mfg. Co., *Cleveland, Ohio.*

SCRIBNER, W. L., plant engineer, Bock Bearing Co., *Toledo, Ohio.*

SLADKY, JOSEPH F., designer, Nash Motors Company, *Kenosha, Wis*

SLAGHT, W WHITNEY, experimental engineering, Pierce Arrow Motor Car Co., *Buffalo, N. Y.*

SMITH, J. W., mechanical engineer, 1135 South 58th St., *Philadelphia.*

STANLEY, R. W., general manager, New York Branch, General Electric Co., *New York.*

STERN, LAWRENCE G., airplane constructor, Standard Aircraft Corp., *Elizabeth, N. J.*

STOUGH, KENNETH K., detail and layout draftsman, Haynes Automobile Co., *Kokomo, Ind.*

STOUT, WALTER D., purchasing agent, Cole Motor Car Co., *Indianapolis.*

STURDIVANT, ARMYDIS, chief draftsman, Warner Gear Co., *Muncie, Ind.*

SUTTON, F. W., general superintendent, Dayton Wright Airplane Co., *Dayton, Ohio.*

TIEDEMANN, HENRY, service engineer, Splitdorf Electrical Co., 98 Warren St., *Newark, N. J.*

TIETSCHE, PAUL W., tool design checker, Nordyke & Marmon Co., *Indianapolis, Ind.*

TOBIN, B. F., president, Continental Motors Corp., *Detroit.*

TURNER, J. E., manager, Bernard & Turner Auto Co., *Des Moines, Iowa.*

UHL, HENRY W., designing engineer, Eisemann Magneto Co., *Brooklyn, N. Y.*

VER LINDEN, EDWARD, president, Olds Motor Works, *Lansing, Mich.*

WARNER, CHARLES F., designer, Sheffield Car Co., *Three Rivers, Mich.*

WARRINGTON, CHESTER H., president and sole owner, Warrington Motor Car Co., *Washington.*

WATERMAN, J. M., production engineer, Canadian Aeroplanes, Ltd., *Toronto, Can.*

WEBER, WALTER HENRY, research engineer, Zenith Carburetor Co., *Detroit, Mich.*

WEBSTER, R. C., works manager, Parrett Tractor Co., *Chicago.*

WELLS, R. W., president, treasurer and manager, Menominee Motor Truck Co., *Menominee, Mich.*

WHIPPLE, F. G., factory representative, Republic Motor Truck Co., *Alma, Mich.*

WISE, K. M., engineer, Detroit Testing Laboratory, *Detroit, Mich.*

WISSEL, E. J., instructor, University of Cincinnati, *Cincinnati.*

ZIEGLER, CLINTON T., assistant engineer and sales, Walden W. Shaw Livery Co., *Chicago.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Aug. 14 and Sept. 19, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

BAUER, LOUIS E. (M) district manager of production, Bureau of Aircraft Production, Dayton, (mail) Bauer Bros. Co., *Springfield, Ohio.*

BEASLEY, W. F. (M) chief draftsman, Engineering Division, Motor Equipment Section, Ordnance Department, *Washington,* (mail) 504 Park Road.

BRANDIMORE, J. C. (A) executive assistant, Mitchell Motors Co., Inc., *Racine, Wis.*

CAMPBELL, W. R. (A) head of tools machine shop, Premier Motor Corp., *Indianapolis,* (mail) 969 West 32nd St.

CHOWN, R. D. (A) draftsman, The Glenn L. Martin Co., *Cleveland,* (mail) 7809 Melrose Ave.

CLOSE, L. W. (M) assistant engineer, The Standard Parts Co., Cleveland, (mail) 1624 Holyoke Ave., *E. Cleveland.*

CRAWFORD, DAVID F. (J) designing engineer, Lyons Atlas Co., *Indianapolis,* (mail) 1108 College Ave.

FITZSIMMONS, J. T. (M) acting research engineer, Dayton Engineering Laboratories Co., *Dayton,* (mail) 42 E. McPherson St.

GEILKER, WALTER L. (J) designing engineer, Lyons Atlas Co., *Indianapolis,* (mail) 2018 Cornell Ave.

GOLDSBOROUGH, PAUL (A) captain, Aviation Section, Signal Reserve Corps, Carlstrom Field, *Arcadia, Fla.*

GOODWIN, JULIUS K. (A) secretary and treasurer, Jackes-Evans Mfg. Co., *St. Louis.*

HAGGOTT, W. S. (J) assistant cable sales manager, The Packard Electric Co., *Warren, Ohio.*

HUBBARD, BURTT J. (M) chief engineer, Apperson Bros. Automobile Co., *Kokomo, Ind.*

KAMPS, G. B. (M) mechanical engineer, The Four Drive Tractor Co., *Big Rapids, Mich.* (mail) 322 S. Warren Ave.

LEWIS, GEORGE W. (M) engineer, Clarke Thomson Research, Philadelphia, (mail) 16 Princeton Ave., *Swarthmore, Pa.*

MARTINDALE, THOMAS B. (A) proprietor Thomas B. Martindale, 3437 N. Broad St., *Philadelphia.*

NEWBOLD, GEORGE (A) business manager, The Gardner-Moffat Co., Inc., 120 W. 32nd St., *New York.*

ROBERTSON, ROBERT B. (A) sales manager and secretary, The Sturtevant-Jones Co., 1214 Jefferson Ave., *Toledo, Ohio.*

SCHICKEL, NORBERT H. (M) designing and production engineer, The Schickel Motor Co., *Stamford, Conn.,* (mail) 94 Forest St.

THOMAS, GERALD WAINE (J) draftsman, Service Motor Truck Co., *Wabash, Ind.,* (mail) 52 S. Main St.

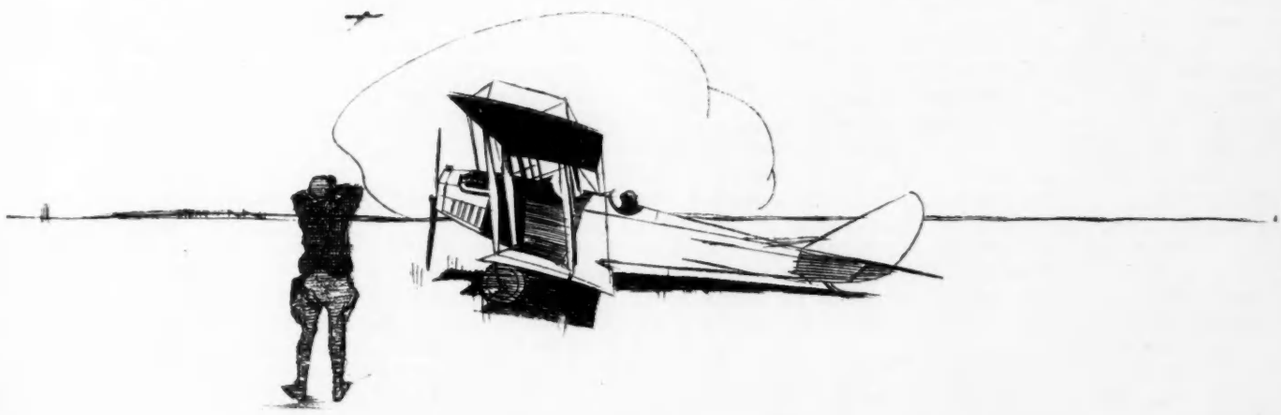
THOMAS, J. W. (M) general superintendent of factories, Firestone Tire & Rubber Co., *Akron, Ohio,* (mail) 82 Atlas St.

TILT, ALBERT (M) naval constructor, Bureau of Construction & Repair, U. S. Navy, *Washington,* (mail) 1801 16th St. N. W.

TUTTLE, J. C. (M) manager of development department, Firestone Tire & Rubber Co., *Akron, Ohio.*

VAN DAM, LORING (J) ensign, U. S. N. R. F., Bureau of Ordnance, Navy Department, *Washington.*

ZWALLY, E. L. (A) road engineer, experimental work, Mitchell Motors Co., Inc., *Racine, Wis.*



Book Reviews *for* S.A.E. Members

This section of THE JOURNAL is devoted to the technical books considered to be of interest to members of the Society. Such books will be described briefly as soon as possible after their receipt, the purpose being to show concisely the general nature of their contents and to give an estimate of their value.

TRUCKING TO THE TRENCHES: Letters from France. By John Iden Kautz. Published by Houghton, Mifflin Co., Cambridge, Mass. Cloth, 5 by 7½ in., 173 pages. Price $1.00 net.

These everyday happenings of six months' trucking service close to the front are fresh, very intimate and interesting. The truck driver gets closer to the field of action than the ambulance driver, is in greater danger, and goes through more experiences. The mental and spiritual poise of the very young writer excites our admiration, while his subject matter is quite out of the line usually taken in war stories. A few paragraphs are quoted.

"I suspect you cannot realize the magnitude of it. Imagine all the traffic on Michigan Boulevard turned into trucks and horses, going on roads one-third as wide, day and night, every road leading up to the front, a distance greater than that from Indianapolis to Chicago. The other day we passed five solid miles of horses and guns going up—a wonderful sight. Think what it takes to feed the horses and men, and then multiply by thousands. Beyond the rail terminals all this must be hauled by horses and motor cars. Then there are the shells. We are one section of twenty-four cars out of more than 200,000, yet every load of our shells, exclusive of the cars, is worth between $78,000 and $100,000. We are learning to shrug and say 'C'est la guerre' in the best French fashion. . . ."

"The other day we carried our first load of supplies. The twenty-four cars of the train load at a supply park and wind slowly up and down through the hills. The distant boom of the guns sounds like the portentous muttering of an oncoming thunderstorm. We come close to the fight, perhaps even within sight of smoking batteries, but not nearer. There is more danger, we are told, of getting a nasty spill than of being hit by shells. Most of our work is just hard plugging, jarring, straining labor with the 5-ton loads, which may be anything from logs to shells or nitroglycerin. It rains too much here. Sometimes for a week the game is mostly sliding sideways down the hills, eyes shut, praying that the other fellow will be able to keep his distance. When we go up closer to the front it is always at night, and there are no lights, not even cigarettes. We work largely at night. One hardly knows whether to be glad or not for the moonlight, since it makes us a good target. Last night we were in a rather nasty place when a Boche was bombing a quarry on one side of us and the French were firing on an airplane directly overhead. We did some lively moving for five minutes and got out of it. We play it pretty safe by taking two cars at a time past dangerous points during intervals in firing. We hauled thousands and thousands of shells for the 'second Verdun.' For the past three days we have been in the supply park not more than four consecutive hours.

"We have been under fire, of course, but the experience, even the first, was much less terrifying than I had anticipated. Somehow, they do not seem to get us. The men take unholy chances sometimes for the sake of seeing all there is to see, but a fool's Providence takes care of them.

"I have seen a little bit of everything doing now, I guess, except the actual trench fighting. I have been in the third-line trenches. It is indescribable, often nauseating. Perhaps it is well that life in the trenches is only vaguely pictured by the people at home."

TECHNICAL ANALYSIS OF BRASS AND THE NON-FERROUS ALLOYS. Second Edition. By William B. Price and Richard K. Meade. Published 1917 by John Wiley and Sons, New York. Cloth, 5 by 7⅞ in., 376 pages, ill. Price $3.

This volume presents concisely, for the benefit of the chemist and metallurgist, the methods usually employed in the chemical analysis of the more common non-ferrous alloys. The subject matter is divided into four parts, as follows: I, Introduction; II, Determination of the metals; III, Some applied examples of alloy analysis; IV, Control and analysis of plating solutions.

Part I describes the uses of engineering alloys, such as bearing metals, solders and fusible alloys, foundry and rolling-mill alloys, and others employed for special purposes. Several tables showing the constituents of these metals are included in this section. Apparatus for electrochemical analysis is also described at length.

Part II gives in detail the procedure to be followed in determining by different methods the elements present in the various alloys.

The rarer metals, such as vanadium, chromium and titanium, formerly used entirely in the ferrous industries, have been used recently to considerable extent in the non-ferrous fields, mostly in the form of alloys, such as chrome copper, titanium copper and vanadium copper. Methods for the complete analysis of these alloys will be found in Part III. In addition, this section contains numerous applied examples of the analysis of other alloys.

Until recent years the successful plater has kept his solutions in working order largely by rule of thumb, and when anything out of the ordinary routine happened he was at loss how to remedy the trouble. It has now become necessary for him to intelligently analyze his solutions. This fact is so evident that the plating trade has gone to much trouble and expense to acquire the necessary knowledge. The busy analyst is also often called upon to analyze plating solutions, and from the analysis make suggestions for their control. For these reasons the authors have incorporated in the second edition a section on the analysis and control of plating solutions.

Some of the more important additions to this edition pertain to the iodate method for antimony in babbitt and similar alloys, bismuthate and bimethylgloxime methods for the determination of manganese and nickel, standard methods for the analysis of spelter, the battery assay of copper, and an accurate method for the determination of cadmium in brass, especially in the presence of arsenic. The book concludes with a subject index.